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Title: MAIN ARC IGNITION EQUIPMENT AND MAIN ARC IGNITION CONTROL METHOD OF THE PLASMA CUTTING MACHINE

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Inventors : Yoshihiro YAMAGUCHI et al.

Applicant: KOMATSU INDUSTRIES CORPORATION

Address: 3-6, Akasaka 2-chome, Minato-ku, Tokyo, JAPAN

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(71)出願人　394019082
コマツ産機株式会社
東京都港区赤坂二丁目３番６号

(72)発明者　山口　義博
石川県小松市串町フ１　コマツ産機株式会社粟津工場内

(72)発明者　入山　孝宏
石川県小松市串町フ１　コマツ産機株式会社粟津工場内

(74)代理人　100097755
弁理士　井上　勉

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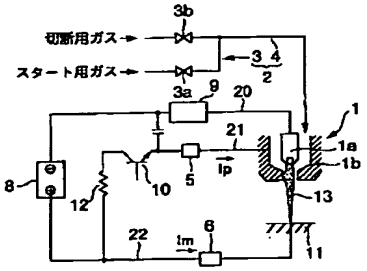
(54)【発明の名称】　プラズマ切断機のメインアーク着火装置及びメインアーク着火制御方法

(57)【要約】
【課題】　プラズマ切断機において、プラズマ電極の寿命とノズル寿命とを共に延長できるメインアーク着火及びメインアーク着火制御方法を提供する。
【解決手段】　プラズマトーチ(1)にプラズマガスを供給する際に、アーク起動前又は直後には、小流量及び／又は低ガス圧でプラズマガスを供給し、プラズマトーチ(1)の電極(1a)とノズル(1b)間にパイロットアーク(16)が着火した後には、プラズマガスを大流量及び／又は高ガス圧に切り替えると共に、前記電極(1a)とワーク(11)間のメインアーク(13)の発生を検出した時には、前記パイロットアーク(16)にパイロット電流(Ip)を供給するパイロット電流回路(21)の、前記ノズル(1b)に繋がるラインに抵抗(12)と直列に挿入された半導体スイッチ(10)により、前記パイロット電流(Ip)を迅速に遮断する。

メインアーク着火装置の概要回路図



1：トーチ
1a：電極
1b：ノズル
2：ガス供給手段
3：ガス切り替え手段
8：プラズマ電源
10：半導体スイッチ
11：ワーク
12：抵抗
13：メインアーク
20：電源ライン
21：パイロット電流回路
22：メイン電流回路
Ip：パイロット電流
Im：メイン電流

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【特許請求の範囲】

【請求項１】　プラズマ切断機のメインアーク着火装置において、

アーク起動前又は直後に、プラズマトーチ(1)に小流量及び／又は低ガス圧でプラズマガスを供給し、パイロットアーク(16)又はメインアーク(13)の着火後には、大流量及び／又は高ガス圧でプラズマガスを供給するように、該ガス流量又はガス圧を切り替えるガス切り替え手段(3)を設けたガス供給手段(2)と、

アーク起動時に、プラズマトーチ(1)の電極(1a)とノズル(1b)間にパイロットアーク(16)を形成する際に、プラズマ電源(8)からノズル(1b)にパイロット電流(Ip)を供給するパイロット電流回路(21)と、

ワーク切断時に、プラズマトーチ(1)の電極(1a)とワーク(11)間にメインアーク(13)を形成する際に、プラズマ電源(8)からメインアーク(13)にメイン電流(Im)を供給するメイン電流回路(22)と、

前記メイン電流回路(22)のワーク(11)に繋がるラインに設けた、メイン電流(Im)を検出するメイン電流検出器(6)とを有し、

前記パイロット電流回路(21)のノズル(1b)に繋がるラインに、前記メイン電流検出器(6)によりメイン電流(Im)を検出した後、前記パイロット電流(Ip)を遮断する半導体スイッチ(10)を備えたことを特徴とするプラズマ切断機のメインアーク着火装置。

【請求項２】　前記パイロット電流回路(21)のノズル(1b)に繋がるラインに、前記半導体スイッチ(10)と直列に抵抗(12)を挿入したことを特徴とする請求項１記載のプラズマ切断機のメインアーク着火装置。

【請求項３】　アーク起動前又は直後に、プラズマトーチ(1)に小流量及び／又は低ガス圧で供給する前記プラズマガスが、窒素又は比較的多く窒素を含むガスであることを特徴とする請求項１記載のプラズマ切断機のメインアーク着火装置。

【請求項４】　プラズマ切断機のメインアーク着火制御方法において、

プラズマトーチ(1)にプラズマガスを供給する際に、アーク起動前又は直後には、小流量及び／又は低ガス圧でプラズマガスを供給し、プラズマトーチ(1)の電極(1a)とノズル(1b)間にパイロットアーク(16)又はメインアーク(13)が着火した後には、プラズマガスを大流量及び／又は高ガス圧に切り替えると共に、

前記電極(1a)とワーク(11)間のメインアーク(13)の発生を検出した時には、前記パイロットアーク(16)にパイロット電流(Ip)を供給するパイロット電流回路(21)の、前記ノズル(1b)に繋がるラインに抵抗(12)と直列に挿入された半導体スイッチ(10)により、前記パイロット電流(Ip)を迅速に遮断することを特徴とするプラズマ切断機のメインアーク着火制御方法。

【発明の詳細な説明】

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【０００１】

【発明の属する技術分野】本発明は、プラズマ切断機のメインアーク着火装置およびメインアーク着火制御方法に関し、特には、アーク起動を頻繁に繰り返す切断作業でもプラズマ電極およびノズルの寿命の延長が図れるメインアーク着火装置およびそのメインアーク着火制御方法に関する。

【０００２】

【従来の技術】従来、金属板材（以後、ワークという）のプラズマアーク熱切断において、そのプラズマ電極およびノズルの劣化が直接加工品質を落とすこと、また、電極およびノズルの交換の際のランニングコストが嵩むことから、これらの寿命に関し種々の研究開発がされ続けてきている。

【０００３】まず、本発明の理解を易しくするために、プラズマ切断機の従来技術として、最も基本的な、プラズマガスとして酸素を用いる切断機およびその制御方法を、プラズマ切断機の一般的構成およびプラズマアーク起動方法を表した図４と、このプラズマ切断機のアーク起動制御方法を表した動作シーケンスのタイムチャートである図５とを参照して説明する。図４(a)と図５とにおいて、プラズマ切断機に起動信号ＳＴが入力されると、定電流電源８が作動し、スイッチ（電磁開閉器）１４が閉じて、プラズマトーチ１内の電極１ａがマイナスに、ノズル１ｂおよびワーク１１がプラスとなるように直流電圧が印加される。と同時に、止め弁１５が開いて、プラズマトーチ１内にプリフローとしての酸素ガスが供給される。このプリフローはガス管路４内の空気を完全に酸素に置換すると共に、ガス流量が安定するまでの時間的余裕を得るために設けられたものである。上記プリフローの後、図４(ｂ)において、高周波発生器９が作動して電極１ａとノズル１ｂとの間に高周波高電圧が印加されると、該電極１ａと該ノズル１ｂとの間に火花放電が起こり、図４(ｃ)に示すように、この火花放電を種として、電極１ａとノズル１ｂとの間にパイロットアーク１６が形成され、定電流電源８から抵抗１２及びスイッチ１４を介してノズル１ｂ、そしてパイロットアーク１６から電極１ａを経由して定電流電源８に戻る回路をパイロット電流Ｉｐが流れる。この時、簡単には、定電流電源８は最大出力を出す状態であり、つまりほぼ定電圧源として機能しているため、前記パイロット電流Ｉｐは抵抗１２によって垂下特性が与えられ、電源特性とアーク電圧とが平衡した状態で安定する。

【０００４】そして、図４(ｄ)に示すように、このパイロットアーク１６を先導として、電極１ａとノズル１ｂとの間に電気的導通が確保されると、前記パイロット電流Ｉｐの一部がメイン電流Ｉｍとなってワーク１１に流れ、メインアーク１３を形成する。これを図示しない電流検出器で検出し、図４(ｅ)に示すように、ノズル１ｂに繋がるスイッチ１４を切り離すことにより、メインア

ーク１３だけの回路となり、メイン電流Ｉｍのみが流れる。そして、予め設定された切断電流値（メイン電流Ｉｍ)を維持するように、図示しない電流検出器の出力値と該設定値とを比較しながら、定電流制御が行われ、ワーク１１の切断加工が実施される。その後、切断終了時には、停止信号ＳＰが電源に投入され、電源の出力が停止し、メインアーク１３への電力の供給が止まり、メインアーク１３が消滅する。

【０００５】以上の如く、従来技術として、パイロット回路に直列に抵抗とスイッチ（電磁開閉器）とを入れ、パイロットアークが発生した後、メインアーク検出手段によりメインアークを検出し、この検出信号により前記スイッチ（電磁開閉器）を開いてパイロットアークを遮断し、メインアークを着火させることは、プラズマ切断機において極一般的に行われている技術である。

【０００６】これまで、プラズマ切断機における技術課題として、まず、消耗品の長寿命化があり、そのために数々の発明、考案がなされてきた。その第１の先行技術として、特開平５－１０４２５１号公報がある。この公報には、プラズマトーチへ供給するプラズマガスの流し方として、プラズマガスをアーク着火直後に、低ガス圧から高ガス圧に、あるいは小流量から大流量に切り替える技術により、電極消耗の低減効果があったと報告されている。

【０００７】また、第２の先行技術として提示する特開平３－２５８４６４号公報には、アーク起動時、アーク起動前又は直後には、プラズマガスとして非酸化性気体をプラズマトーチへ供給し、アーク着火後は、プラズマガスを酸化性気体に切り替える技術が開示されており、このガス種類の切り替え技術により、電極消耗を低減でき、電極寿命を延長できるとしている。

【０００８】そして、第３の先行技術として提示する特開平６－１５４５７号公報には、パイロットアークからメインアークへの移行性を改善するため、メインアークの着火検出信号によりスイッチを開いてパイロットアークを遮断する際の前記スイッチとして、電磁開閉器ではなくトランジスタを採用した技術が記載されている。この技術は、パイロット電流の２次側チョッパ制御に関するもので、トランジスタを単純なスイッチとしてではなくチョッパ制御素子として機能させている。そして、メインアークの回路は、パイロットアーク発生中はフル出力し、移行に必要な電極と母材間又はノズルと母材間の電圧を充分に大きく取れることから、メインアークへの移行ミス、移行遅れを防止し、好適な電源装置を提供できるとしている。

【０００９】

【発明が解決しようとする課題】従来、前記第１の先行技術として提示した特開平５－１０４２５１号公報、および第２の先行技術として提示した特開平３－２５８４６４号公報などに見られるように、電極の寿命延長のみに関する技術は存在していた。しかしながら、これら従来技術のプラズマガス切り替えに関して、起動時に小流量又は低圧ガスにすると、パイロットアークからメインアークへの移行性が悪くなり、むしろノズルのダメージが大きくなる不具合が発生することが最近解ってきた。また、窒素又は窒素を多く含むガスでは、メインアークへの移行性が酸素よりも悪くなり、ノズルにとってはダメージが大きくなることも解ってきた。すなわち、ガス切り替えは電極寿命向上には大きく寄与するが、ノズル寿命については、改善が見られないか、あるいは逆効果にさえなることが解ってきた。従って、電極寿命が長くなっても、それ以前にノズルが寿命に達し、これら消耗品の交換インターバルは期待するほど長くはならなかった。譬えこの技術を採用して、電極寿命が改善（アーク着火回数にして２００回程度から６００回程度に）されても、ノズルの寿命に関しては、アーク着火回数にして精々１５０～２００回程度であり、改善されていないのが実情である。

【００１０】ノズルのダメージの要因としては、以下の２つに大別できる。即ち、ピアッシング工程（穴開け工程）時にノズルに向かって吹き上がってくる溶融金属（スパッタ）が、ノズルに付着することで、ノズルがダメージを受ける、言わば外的要因によるケースと、パイロットアークからメインアークに移行するまでに、パイロットアークによってノズルに電流が流入し、ノズルの出口部分が溶融されることによるダメージとに分けられる。これらノズルの寿命に悪影響を及ぼす要因の改善策としては、従来、前者の外的なダメージについては、ノズルの外側にシールドキャップを設けることでスパッタからノズルを保護する方法があり、現状のプラズマトーチの大部分で採用されている。しかし、前記後者のパイロットアークによるダメージについては、それを軽減する方法は、従来技術では明確な開示が未だ見当らない。要するに、電極寿命とノズル寿命とを同時に延長させ、実用上充分な効果をもたらす技術は従来は存在していなかった。

【００１１】通常、ノズルの寿命は、電極が寿命に至っていない限り、パイロットアークからメインアークへ移行するまでの電極とノズル間における頻繁なパイロットアークによりノズルの出口近傍が溶融されることで徐々にその損傷が拡大され、アークの切れ味が悪くなり、切断加工精度が所定の規定値を下回った段階で寿命と判定されている。

【００１２】一方、電極はアーク起動時、電極表面の温度が約３０００°Ｃの高温まで上昇し、このときの熱衝撃により該電極表面が剥離する形で瞬間的に消耗することが知られているが、ノズル寿命はこの電極寿命に左右される。例えば、電極がある寿命に至った時点で、前述の理由で急激に損傷破壊され、この時ワークを熱切断中のノズルにおいて電極とワーク間のアークが途絶えて、

これに換わってノズルと電極間のアークが発生し、瞬時に（アークがワークを溶かすと同様な原理で）ノズルの出口近傍を溶かしてしまうことになる。このように、電極の瞬時の損傷が発生した場合、これにより所謂、道ずれ的なノズルの損傷が発生し、その直前ではノズルとして未だ充分な切れ味を有して寿命に至っていない場合においても、瞬時に、継続使用が不可能な状態となってしまうのが実状である。以上述べた理由から、従来、ノズル寿命のみの延命策を幾ら講じても、ノズル寿命が電極寿命によって決まるとの実情から、電極のみの寿命延長技術の開発に傾注し、ノズル寿命延長技術と電極寿命延長技術とを関連させた観点で考慮するとの考えには及んでいなかったと言える。

【００１３】また、電極及びノズルについては、その寿命による交換頻度の多さが、電極及びノズルの交換に伴う消耗コストには勿論のこと、機械稼働率低下（生産性低下）にも多大な影響を及ぼしている点も問題である。この問題を解決するためには、電極及びノズルの寿命をそれぞれできる限り延長させ、これらを同時にセット交換する（同一寿命とする）ことが理想であるが、現実は、電極寿命及びノズル寿命それぞれは不揃いであり、かつ前述のように電極の突発的な損傷によりノズル寿命が左右されることから、余裕を見て低めの寿命回数を設定せざるを得ないのが実情であった。

【００１４】また、特開平６－１５４５７号公報に記載のアーク着火技術へのトランジスタの採用は、前述のようにノズル寿命の延長を意図したものではない。しかも、パイロットラインに挿入されたトランジスタは、スイッチとしてだけでなく、パイロット電流を調整するチョッパ素子として使われており、メインアーク電流の定電流制御回路とは別に、前記トランジスタを制御する為の定電流制御回路が必要となり、その電源は複雑となりコスト高となっている。

【００１５】本発明は、上記の問題点に着目してなされ、プラズマ切断機において、プラズマ電極の寿命とノズル寿命とを共に延長できるメインアーク着火装置およびメインアーク着火制御方法を提供することを目的とする。

【００１６】

【課題を解決するための手段、作用及び効果】本発明に際し、発明者らは、電極寿命向上を主に狙った従来のガス切り替え技術に対して、ノズル寿命をも視野に入れた、最適なパイロット回路の着火制御技術について研究開発を行い、以下の結論を得た。

（１）ノズルのダメージはパイロットアーク発生時にノズルに流入する電流により引き起こされ、そのダメージを与える電流の大きさは、プラズマガスが低圧、小流量になるほど大きくなり、そのことが、電極寿命向上に寄与するガス切り替えシステムにおいてはノズル寿命を短くしている。

（２）また、ノズルへの流入電流は、パイロットアーク時のプラズマガスのガス種が窒素を多く含むほど、その流入電流値が増加する傾向にある。

（３）そして、パイロットラインに直列に挿入される抵抗に関しては、定格のパイロットアーク電流値が２０Ａ程度である場合、その抵抗値が２Ω未満のときは、極端にノズルへの流入電流が増加する傾向にある。よって、この場合には、パイロット回路の抵抗値は２Ω以上が望ましい。

（４）ノズル寿命を向上する為には、ノズルへの流入電流の大きさを下げるだけではなく、出来るだけ低いメイン電流の検出のレベルを用いて、一旦メイン電流を検出したら、直ちにパイロット回路を遮断することが、ノズルの損傷を少なくできるので好ましい。従って、メイン電流検出のレベルを低く設定し、検出後、直ちにパイロットアークを遮断すべきであるが、遮断のタイミングが従来の電磁開閉器などの機械的な開閉スイッチを使用すると５０msec程度遅れるので、半導体スイッチ（トランジスタ、サイリスタ、ＩＧＢＴなど）を使用するのが望ましい。また、この場合、半導体スイッチは純粋にスイッチとして使用し、前述した特開平６－１５４５７号公報に開示された技術のようなチョッパ制御は行わない。以上の如く研究開発により得た上記の結論を盛り込むことにより、前述の消耗品の寿命延長に関する課題を解決できたので、その達成手段および効果を以下に説明する。

【００１７】上記の本願発明の目的を達成するために、第１発明は、プラズマ切断機のメインアーク着火装置において、アーク起動前又は直後に、プラズマトーチに小流量及び／又は低ガス圧でプラズマガスを供給し、パイロットアーク又はメインアークの着火後には、大流量及び／又は高ガス圧でプラズマガスを供給するように、該ガス流量又はガス圧を切り替えるガス切り替え手段を設けたガス供給手段と、アーク起動時に、プラズマトーチの電極とノズル間にパイロットアークを形成する際に、プラズマ電源からノズルにパイロット電流を供給するパイロット電流回路と、ワーク切断時に、プラズマトーチの電極とワーク間にメインアークを形成する際に、プラズマ電源からメインアークにメイン電流を供給するメイン電流回路と、前記メイン電流回路のワークに繋がるラインに設けた、メイン電流を検出するメイン電流検出器とを有し、前記パイロット電流回路のノズルに繋がるラインに、前記メイン電流検出器によりメイン電流を検出した後、前記パイロット電流を遮断する半導体スイッチを備えた構成としている。

【００１８】第１発明では、先ず、電極とノズル間にパイロットアークを形成する際に、ガス切り替え手段により、アーク起動前又は直後には電極とノズル間に流すプラズマガスを小流量及び／又は低ガス圧としたので、パイロットアークをワーク側に吹き流す力が小さくなり、

その結果、ノズルに入るパイロット電流Ｉｐが流れ易くなり、このパイロット電流Ｉｐが小電流でもアークの形成が可能となる。また、一方、電極はアーク生成時、このときの熱衝撃により該電極表面が剥離する形で瞬間的に消耗することが知られているが、パイロット電流Ｉｐが小電流で済むことからアーク点弧時に前記熱衝撃による電極のダメージを大幅に低減できる。

【００１９】第１発明によると、次に、前記ガス切り替え手段により、パイロットアーク又はメインアークの着火後に、電極とノズル間に大流量及び／又は高ガス圧のプラズマガスを供給するので、パイロットアークをワーク側に吹き流す力が大きくなり、電極とノズル間でパイロット電流Ｉｐが流れ難くなる。そして、プラズマ電源の電流はパイロット電流Ｉｐとメイン電流Ｉｍとに分流しているので、パイロット電流Ｉｐが減れば、反対にメイン電流Ｉｍが増加する。この結果、パイロットアークから、電極とワーク間でのメインアークへの移行が極めて速やかに行われる。また、アーク着火による前記熱衝撃による電極の消耗は低ガス圧雰囲気のため少なくなる。上記のように、ガス供給手段にガス切り替え手段を設け、アーク起動前又は直後に小流量及び／又は低ガス圧でプラズマガスを供給し、パイロットアーク又はメインアークの着火後には大流量及び／又は高ガス圧に切り替えることにより、電極の寿命は、アーク着火回数で約６００回程度まで格段に向上できた。

【００２０】また、第１発明では、パイロット電流を遮断するためにトランジスタを採用した構成により、前述した電極寿命の延長の効果に加えて、次に述べるような飛躍的なノズル寿命の延長の効果をも得ることができた。パイロットアークから、電極とワーク間のメインアークへ移行した後においても、電極とノズル間では依然としてアークの一部が接続され、ノズルへパイロット電流Ｉｐが流れている状態が継続しているが、このため、ノズル口先端の出口部分は前記アークにより常に溶融されている状況にある。従って、ノズル寿命を延ばすためには、このメインアークへ移行した後に、電極とノズル間にパイロット電流Ｉｐが流れている時間をできる限り短くした方が良いわけである、事実、発明者らは実験結果により、パイロットアークによるノズルのダメージは、ノズルに入る電流の大きさと時間に比例する事実を得ている。そこで、メインアーク発生後、ノズルへのパイロット電流Ｉｐを遮断するために、パイロット電流回路のノズルに繋がるラインに、従来の電磁開閉器に換えてトランジスタを採用したので、パイロット電流Ｉｐの遮断時間は従来の電磁開閉器に比べ格段に速く（電磁開閉器の約５０msecに対し、トランジスタでは約５msec）なり、ノズル口先端の出口部分が前記アークにより常に溶融されている時間が激減することから、ノズルの寿命は、従来に較べ約３倍（アーク着火回数で、従来の約１５０回～２００回から約６００回）へと飛躍的に改善された。

【００２１】従来、熱衝撃による電極の突発的な損傷によりノズルも道ずれ的に破損されてしまうなど、電極寿命及びノズル寿命それぞれは不揃いで、余裕を見て低めの寿命回数を設定せざるを得ないのが実情であり、電極寿命及びノズル寿命をそれぞれできる限り延長させ、これらを同時にセット交換する（同一寿命とする）ことが理想であったが、前述のように本第１発明により、電極及びノズルの寿命を共に大幅に改善でき、かつそれぞれの寿命の値は、ほぼ同一（アーク着火回数で、約６００回程度）とすることを可能とした。よって、この電極及びノズルの寿命改善により、寿命による交換頻度を激減でき、交換に伴う消耗品コストの改善は勿論のこと、機械稼働率向上（生産性向上）に多大な効果が得られた。なお、以上の電極寿命とノズル寿命とを同時に延長可能とした技術は、単なる従来技術の組み合わせではなく、ノズル寿命が電極寿命に相関があり、電極寿命を延ばすと同時にノズル寿命の延長が図れないものか、との従来見落としていた観点に着目し、創意工夫の上で本発明に至ったものである。

【００２２】次に第２発明は、第１発明において、前記パイロット電流回路のノズルに繋がるラインに、前記半導体スイッチと直列に抵抗を挿入した構成としている。

【００２３】本発明者らは、前述したように、実験結果から、パイロットアークによるノズルのダメージはノズルに入る電流の大きさと時間に比例する事実を得ており、ノズルのダメージはノズルに入る電流により引き起こされるが、本第２発明によると、パイロット電流回路のノズルに繋がるラインに抵抗を挿入したことで、パイロット電流が低下し、ノズルの損傷を軽減させると共に、プラズマ定電流電源の特性によってパイロット電流の低下に伴ってこれとは逆にメイン電流が増加することにより、メインアークの発生、及びメインアークへの移行を安定的に、かつ迅速に行なうことができる。

【００２４】第３発明は、第１発明において、アーク起動前又は直後に、プラズマトーチに小流量及び／又は低ガス圧で供給する前記プラズマガスが、窒素又は比較的多く窒素を含むガスであることを特徴としている。

【００２５】通常、プラズマ切断では、パイロットアークを着火した直後に、電極中心に埋め込まれている電極材料のハフニュウムは激しく消耗が進行する。本第３発明では、電極周辺に供給するプラズマガスとして窒素又は比較的多く窒素を含むガスを用いたので、電極の先端部に、ハフニュウムの窒化物が形成されることになり、このハフニュウム窒化物は融点が高い為に電極の消耗を少なくできる。したがって、アーク起動時に電極消耗を抑制し、電極寿命を延長できる。

【００２６】また、第４発明は、プラズマ切断機のメインアーク着火制御方法において、プラズマトーチにプラズマガスを供給する際に、アーク起動前又は直後には、

小流量及び／又は低ガス圧でプラズマガスを供給し、プラズマトーチの電極とノズル間にパイロットアーク又はメインアークが着火した後には、プラズマガスを大流量及び／又は高ガス圧に切り替えると共に、前記電極とワーク間のメインアークの発生を検出した時には、前記パイロットアークにパイロット電流を供給するパイロット電流回路の、前記ノズルに繋がるラインに抵抗と直列に挿入された半導体スイッチにより、前記パイロット電流を迅速に遮断する方法としている。

【００２７】第４発明によると、このメインアーク着火制御方法により第１発明と同様に、プラズマ切断機において電極及びノズルの大幅な寿命の延長が図れることから、電極及びノズルの交換頻度を格段に低減でき、電極及びノズルの交換に伴う消耗品コストの低減は勿論のこと、機械稼働率の向上（生産性向上）の多大な効果が得られる。

【００２８】

【発明の実施の形態】以下に、本発明の実施形態を図１、図２及び図３を参照して詳細に説明する。ここに、図１は本発明に係るメインアーク着火装置の概要回路図であり、図２は本発明に係るパイロットアークを表した図である。また、図３は本発明に係るプラズマガスフローのタイムチャートである。なお、図４における構成要素と同じ構成には同一符号を付け、以下での説明を省く。

【００２９】図１において、プラズマ切断機のメインアーク着火装置は、トーチ１へ電力を供給する為のプラズマ電源としての定電流電源８を備えている。定電流電源８のマイナス出力は電源ライン２０を経由してトーチ１の電極１ａに接続され、また定電流電源８のプラス出力は、パイロット電流Ｉｐを供給するパイロット電流回路２１と、メイン電流Ｉｍを供給するメイン電流回路２２との２系統ラインに分岐され、それぞれノズル１ｂとワーク１１に接続されている。

【００３０】前記パイロット電流回路２１には、電極１ａとノズル１ｂとの間に形成したパイロットアーク１６（図２参照）から、電極１ａとワーク１１との間に形成されるメインアーク１３へスムーズに移行させるための抵抗１２と、本発明の特徴であるスイッチング用のトランジスタ１０と、電極１ａとノズル１ｂとの間に流れるパイロット電流Ｉｐを検出するパイロット電流検出器５とが直列に接続されて設けられている。トランジスタ１０のベースには、図示しないコントローラからの制御指令信号が接続されている。ここで、発明者らが行なった実験において、定格パイロットアーク電流が２０Ａ程度である仕様の切断機の場合、上記抵抗１２の抵抗値が２Ω未満であると、極端にノズルへの流入電流が増加する傾向にあるので、その抵抗値は２Ω以上が望ましいことが解った。なお、実験結果によると、抵抗値は４～８Ωが好ましい。また、トランジスタ１０は、スイッチング素子としてＩＧＢＴのような高速で作動するものを採用している。なお、パイロット電流回路２１には、必要に応じて、スイッチング時のサージを吸収するためのダイオード等で構成されるサージ吸収用回路（図示せず）を追加してもよい。

【００３１】また、前記メイン電流回路２２には、図２に示すパイロットアーク１６の先導により図１に示すメインアーク１３が形成されるため、電極１ａとワーク１１との間にメイン電流Ｉｍが流れたことを検出するためのメイン電流検出器６が挿入されている。このメイン電流検出器６にはシャント抵抗やホール素子を用いたカレントトランスを使用し、例えば３アンペア程度の小電流がメイン電流回路２２に流れると、直ちにパイロット電流回路２１のトランジスタ１０をオフし、電極１ａとノズル１ｂとの間に流れているパイロット電流Ｉｐを瞬時に遮断させる構成とする。

【００３２】ノズル寿命を向上する為には、ノズル１ｂへの流入電流の値を下げるだけではなく、出来るだけ低いメイン電流Ｉｍの検出レベルを設定し、この設定検出レベルにより一旦メイン電流Ｉｍを検出したら、直ちにパイロット電流回路２１を遮断することが、ノズルの損傷を少なくできるので好ましい。従って、メイン電流検出のレベルをできる限り低く設定し、検出後、直ちにパイロットアークを遮断すべきであり、本発明ではこの遮断のタイミングを高速化するために、トランジスタ、ＩＧＢＴなどの電子式スイッチ（半導体スイッチ）を使用している。これによって、遮断のタイミングは従来の機械式接点の開閉によると５０msec程度も遅れていたものが、５msec程度に改善することを確認し、これに伴って電極１ａの寿命と共にノズル１ｂの寿命も格段に長期化されることを確認した。

【００３３】また本発明のメインアーク着火装置には、トーチ１にプラズマガスを供給するガス供給手段２として、電極１ａの寿命向上のために、図１に示すような、スタート用ガスの供給または遮断を行うスタート用ガス止め弁３ａと、切断用ガスの供給または遮断を行う切断用ガス止め弁３ｂとを具備したガス切り替え手段３、及びこれらのスタート用ガス止め弁３ａと切断用ガス止め弁３ｂとをトーチ１に接続するガス管路４を設けている。

【００３４】これらスタート用ガス止め弁３ａと切断用ガス止め弁３ｂとの切り替えは、先ず、プリフローからアーク起動までは、スタート用ガス止め弁３ａのみを開き、スタート用のガスをガス管路４を介してトーチ１内の電極１ａとノズル１ｂとの間に形成したガス供給路に供給する。この時のスタート用のガス（プリフロー）については、図３に示すように、切断時のガスに比較して低ガス圧及び／又は低流量であり、また純窒素又は窒素を多く含むガスとしている。次に、電極１ａとノズル１ｂとの間にパイロットアーク１６が発生すると、このパ

イロットアーク１６を通して電極１ａとノズル１ｂとの間に流れるパイロット電流Ｉｐをパイロット電流検出器５が検出し、この検出信号により切断用ガス止め弁３ｂを開いて、プラズマトーチ１に切断用のガスを供給する。この切断用ガスは、図３に示すように前記スタート用ガス（プリフロー）に比較して高ガス圧及び／又は大流量であり、また純酸素又は酸素を多く含むガスである。なお、切断用ガス止め弁３ｂを開いている時、スタート用ガス止め弁３ａは閉じてもかまわないし、またスタート用ガス止め弁３ａと直列に逆止弁を入れておれば開いたままでもよい。

【００３５】本実施形態によると、次のような作用、効果が得られる。

（１）本発明の構成により、電極とノズル間にパイロットアークを形成する際に、その間に流すプラズマガスを小流量及び／又は低ガス圧としたので、パイロットアークをワーク側に吹き流す力が小さくなり、その結果、ノズルに流れるパイロット電流Ｉｐが流れ易くなり、このパイロット電流Ｉｐが小電流でもパイロットアークの形成が可能となる。そして、パイロットアーク生成時に電極とノズルとの間で流れるパイロット電流Ｉｐが小電流で済むことから、アーク点弧時に前記熱衝撃による電極のダメージを大幅に低減できる。

【００３６】次に、本発明によると、プラズマ切断機のメインアーク着火装置において、ガス供給手段にガス切り替え手段を設けた構成により、切断時に電極とノズル間に大流量及び／又は高ガス圧のプラズマガスを流すことから、パイロットアークをワーク側に吹き流す力が大きくなり、電極とノズル間でパイロット電流Ｉｐが流れ難くなる。そして、定電流電源の電流はパイロット電流Ｉｐとメイン電流Ｉｍとに分流しているので、上記のようにパイロット電流Ｉｐが減れば、相対的にメイン電流Ｉｍが増加することになる。この結果、電極とワーク間でのメインアークの発生、及びパイロットアークからメインアークへの移行が極めて速やかに行われる。このように、ガス供給手段にガス切り替え手段を設け、アーク起動前又は直後には、小流量及び／又は低ガス圧でガスを供給し、パイロットアーク着火後又はメインアーク着火後には、大流量及び／又は高ガス圧に切り替えることにより、電極の寿命は、アーク着火回数で、約６００回程度は確保された。

【００３７】（２）また、本発明では、パイロット電流Ｉｐを遮断するために、トランジスタ等の半導体スイッチを採用した。これにより、パイロット電流Ｉｐの遮断時間は従来のような電磁開閉器に比べ格段に速く（電磁開閉器の約50msecに対し、トランジスタでは約５msec）なり、ノズル口先端の出口部分が前記プラズマアークにより常に溶融されている時間が激減することから、ノズルの寿命は、従来に較べ約３倍（アーク着火回数で、従来の約１５０回～２００回から約６００回）と飛躍的に改善された。

【００３８】（３）また、ノズルに接続されるパイロット電流回路に抵抗を挿入し、この抵抗値を２Ω以上とすることで、ノズルへのパイロット電流Ｉｐが低下し、ノズルの損傷を軽減できる。また、これと共に、前述の理由でパイロット電流Ｉｐの低下に伴ってメイン電流Ｉｍが増加することにより、メインアークの発生及びメインアークへの移行が安定して、迅速に行え、ノズル寿命及び電極寿命を大幅に延ばすことができる。さらに、上記抵抗値を大きくしたことにより、ノズルとワーク間の電位差が大きくなるので、メインアークへの移行が容易にできる。

【００３９】（４）プラズマ切断では、電極にパイロットアークを着火した直後に、電極中心に埋め込まれている電極材料のハフニュウムは、激しく消耗が進行することになるが、本発明では、電極周辺のプラズマガスとして窒素又は窒素を多く含むガスを用いたので、電極の先端部にハフニュウムの窒化物が形成されることになり、このハフニュウム窒化物は融点が高い為、電極消耗を少なくできる。従って、アーク起動時に電極消耗を抑制し、電極寿命を延ばす効果が得られた。なお、アーク起動時に、窒素を使用することによるメインアーク移行性の低下によるノズルダメージの増加を、半導体スイッチを利用したことにより排除している。

【００４０】（５）前述のような本発明の構成により、電極及びノズルの寿命を共に大幅に改善でき、かつそれぞれの寿命の長さはほぼ同一（アーク着火回数で、約６００回程度）とすることを可能とした。よって、この電極及びノズルの寿命改善により、長いインターバルでの電極及びノズルのセット交換を可能とし、その交換頻度を激減でき、電極及びノズルの交換に伴う消耗品コストの改善は勿論のこと、機械稼働率向上（生産性のアップ）に多大な効果が得られる。

【図面の簡単な説明】

【図１】本発明に係るメインアーク着火装置の概要回路図である。

【図２】本発明に係るパイロットアークを表した図である。

【図３】本発明に係るプラズマガスフローのタイムチャートである。

【図４】従来技術のプラズマ切断機の一般的構成及びプラズマアーク起動方法の説明図である。

【図５】従来技術のアーク起動制御方法を表した動作シーケンスのタイムチャートである。

【符号の説明】

１…トーチ、１ａ…電極、１ｂ…ノズル、２…ガス供給手段、３…ガス切り替え手段、３ａ…スタート用ガス止め弁、３ｂ…切断用ガス止め弁、４…ガス管路、５…パイロット電流検出器、６…メイン電流検出器、８…定電流電源（プラズマ電源）、９…高周波発生器、１０…ト

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ランジスタ（半導体スイッチ）、１１…ワーク、１２…抵抗、１３…メインアーク、１４…スイッチ(電磁開閉器)、１５…止め弁、１６…パイロットアーク、２０…＊

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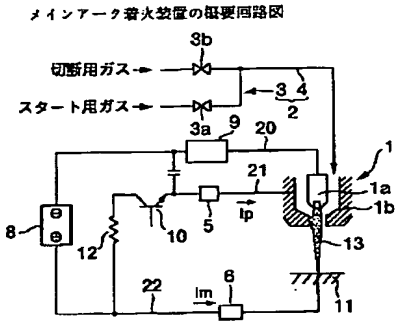
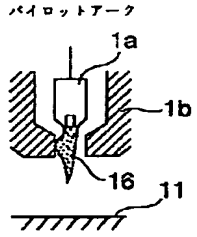
＊電源ライン、２１…パイロット電流回路、２２…メイン電流回路、Ｉｐ…パイロット電流、Ｉｍ…メイン電流。

【図１】



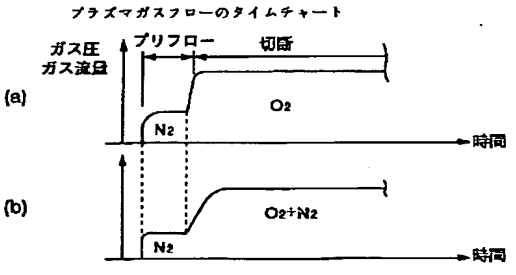
【図２】



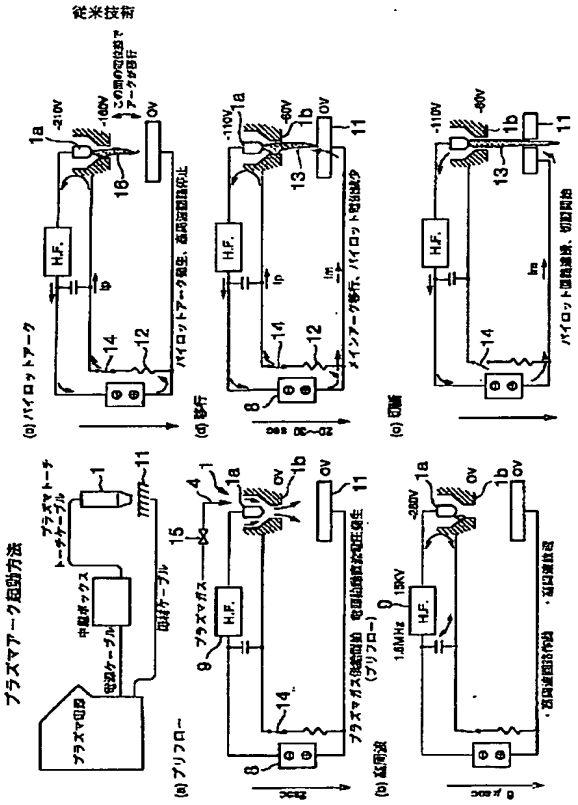
16：パイロット電流

1：トーチ
1a：電極
1b：ノズル
2：ガス供給手段
3：ガス切り替え手段
8：プラズマ電源
10：半導体スイッチ
11：ワーク
12：抵抗
13：メインアーク
20：電源ライン
21：パイロット電流回路
22：メイン電流回路
Ip：パイロット電流
Im：メイン電流

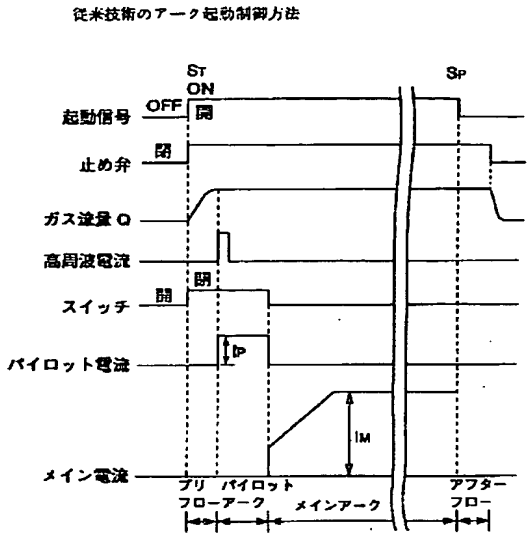
【図３】



【図４】



【図５】



フロントページの続き

(72)発明者　加端　哲也
石川県小松市串町フ１　コマツ産機株式会
社粟津工場内

Ｆターム(参考)　4E001 AA01 BB11

JAPANESE [JP,2003-225768,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

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CLAIMS

[Claim(s)]
[Claim 1] The main arc ignition equipment of the plasma cutting machine characterized by providing the following An arc starting front stirrup is the gas supply means (2) which established the gas change means (3) which changes this quantity of gas flow or gas pressure so that plasma gas might be supplied to a plasma torch (1) with a small flow rate and/or low gas pressure and plasma gas might be supplied with a large flow rate and/or high gas pressure after ignition of a pilot arc (16) or a main arc (13) immediately after. The pilot-current circuit which supplies a pilot current (Ip) to a nozzle (1b) from a plasma power supply (8) in case a pilot arc (16) is formed between the electrode (1a) of a plasma torch (1), and a nozzle (1b) at arc during starting (21) The main current circuit which supplies main current (Im) to a main arc (13) from a plasma power supply (8) in case a main arc (13) is formed between the electrode (1a) of a plasma torch (1), and a work (11) at the time of work cutting (22) The solid state switch which intercepts the aforementioned pilot current (Ip) after the aforementioned main current detector (6) detects main current (Im) on the line which has the main current detector (6) which was formed in the line connected with the work (11) of the aforementioned main current circuit (22), and which detects main current (Im), and is connected with the nozzle (1b) of the aforementioned pilot-current circuit (21) (10)
[Claim 2] The main arc ignition equipment of the plasma cutting machine according to claim 1 characterized by inserting resistance (12) in the line connected with the nozzle (1b) of the aforementioned pilot-current circuit (21) in series with the aforementioned solid state switch (10).
[Claim 3] An arc starting front stirrup is the main arc ignition equipment of the plasma cutting machine according to claim 1 with which the aforementioned plasma gas supplied to a plasma torch (1) with a small flow rate and/or low gas pressure immediately after is characterized by being nitrogen or gas containing comparatively many nitrogen.
[Claim 4] In case plasma gas is supplied to a plasma torch (1), in the main arc ignition control method of a plasma cutting machine, an arc starting front stirrup in immediately after After it supplies plasma gas with a small flow rate and/or low gas pressure and a pilot arc (16) or a main arc (13) lights between the electrode (1a) of a plasma torch (1), and a nozzle (1b) While changing plasma gas to a large flow rate and/or high gas pressure, when generating of the main arc (13) between the aforementioned electrode (1a) and a work (11) is detected By the solid state switch (10) inserted in the line connected with the aforementioned nozzle (1b) of the pilot-current circuit (21) which supplies a pilot current (Ip) to the aforementioned pilot arc (16) in series with resistance (12) The main arc ignition control method of the plasma cutting machine characterized by intercepting the aforementioned pilot current (Ip) quickly.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] Especially this invention relates to the main arc ignition equipment to which cutting which repeats arc starting frequently can aim at extension of the life of a plasma electrode and a nozzle, and its main arc ignition control method about the main arc ignition equipment of a plasma cutting machine, and the main arc ignition control method.
[0002]
[Description of the Prior Art] Since the running cost in the case of exchange of that degradation of the plasma electrode and a nozzle lowers the quality of a direct workpiece, an electrode, and a nozzle increases conventionally in the plasma-arc cutting process of metal plate material (it is henceforth called a work), various research and development continued being done about these lives.
[0003] first, in order to make an understanding of this invention easy, drawing 4 which expressed the general composition and the plasma-arc starting method of a plasma cutting machine for the most fundamental cutting machine that uses oxygen as plasma gas, and its control method as conventional technology of a plasma cutting machine, and drawing 5 which is the timing diagram of the operating sequence showing the arc starting control method of this plasma cutting machine are illuminated 3, and is explained In drawing 4 (a) and drawing 5 , if a seizure signal ST is inputted into a plasma cutting machine, a constant current power supply 8 will operate, a switch (electromagnetic switch) 14 will close, and direct current voltage will be impressed so that nozzle 1b and a work 11 may be [electrode 1a in a plasma torch 1] added at minus. Simultaneously, a stop valve 15 opens and the oxygen gas as a pulley flow is supplied in a plasma torch 1. This pulley flow is established in order to acquire a time margin until a quantity of gas flow is stabilized, while replacing the air in the gas pipe way 4 by oxygen completely. If a high frequency generator 9 operates and the RF high voltage is impressed between electrode 1a and nozzle 1b in drawing 4 (b) after the above-mentioned pulley flow, as spark discharge happens between this electrode 1a and this nozzle 1b and it is shown in drawing 4 (c) A pilot arc 16 is formed between electrode 1a and nozzle 1b by using this spark discharge as a seed. A pilot current Ip flows the circuit which returns to a constant current power supply 8 via electrode 1a from nozzle 1b and a pilot arc 16 through a constant current power supply 8 to resistance 12 and a switch 14. It is in the state where a constant current power supply 8 takes out the maximum output simply at this time, that is, the drooping characteristic is given by resistance 12, and since it is functioning as a source of a constant voltage mostly, the aforementioned pilot current Ip is stabilized after a power requirement and arc voltage have balanced.
[0004] And if an electric flow is secured between electrode 1a and nozzle 1b by considering this pilot arc 16 as guidance as shown in drawing 4 (d), a part of aforementioned pilot current Ip will turn into main current Im, it will flow to a work 11, and will form the main arc 13. As the current detector which does not illustrate this detects and it is shown in drawing 4 (e), by separating the switch 14 which leads to nozzle 1b, it becomes the circuit of only the main arc 13 and only main current Im flows. And cutting current value set up beforehand (main current Im) Comparing the

output value and this set point of a current detector which are not illustrated so that it may maintain, constant current control is performed and cutting processing of a work 11 is carried out. Then, at the time of a cutting end, a stop signal SP is supplied to a power supply, the output of a power supply stops, supply of the power to the main arc 13 stops, and the main arc 13 disappears.

[0005] A main arc detection means detecting a main arc, and this detecting signal opening the aforementioned switch (electromagnetic switch), intercepting a pilot arc, and lighting a main arc, after it puts resistance and a switch (electromagnetic switch) into a pilot circuit in series as conventional technology and a pilot arc occurs like the above is the technology currently very generally performed in the plasma-cutting machine.

[0006] As a technical technical problem in a plasma cutting machine, first, the reinforcement of an article of consumption occurs and, for the reason, much invention and the design have so far been made. There is JP,5-104251,A as the 1st advanced technology. It is reported to this official report as how to pass the plasma gas supplied to a plasma torch by the technology which changes plasma gas to the high gas pressure from low gas pressure, or a large flow rate from a small flow rate just behind arc ignition that there was the reduction effect of an electrode wear.

[0007] Moreover, arc during starting and an arc starting front stirrup supply a non-oxidizing quality gas to a plasma torch as plasma gas immediately after, the technology which changes plasma gas to an oxidizing quality gas is indicated by JP,3-258464,A shown as the 2nd advanced technology, with the change technology of these types of gas, an electrode wear can be reduced and after arc ignition supposes at it that an electrode life will be extensible.

[0008] And in order to improve the translatability from a pilot arc to a main arc, the technology which adopted not an electromagnetic switch but the transistor is indicated by JP,6-15457,A shown as the 3rd advanced technology as the aforementioned switch at the time of the ignition detecting signal of a main arc opening a switch, and intercepting a pilot arc. About secondary chopper control of a pilot current, this technology is not considering a transistor as a simple switch, and is operated as a chopper control element. And during pilot-arc generating, since the circuit of a main arc carries out a full output and can take the voltage large enough between an electrode required for shift, and a base material, or between a nozzle and a base material, it prevents the shift mistake to a main arc, and shift delay, and supposes that a suitable power unit can be offered.

[0009]

[Problem(s) to be Solved by the Invention] The technology only about the life extension of an electrode existed so that JP,5-104251,A shown as the 1st advanced technology of the above, JP,3-258464,A shown as 2nd advanced technology might see conventionally. However, if it is made a small flow rate or low voltage gas about the plasma-gas change of these conventional technology at during starting, it has turned out that the fault to which the translatability from a pilot arc to a main arc becomes bad, and the damage of a nozzle becomes large rather occurs recently. Moreover, by the gas containing many nitrogen or nitrogen, the translatability to a main arc became worse than oxygen, and a damage understands it also as a bird clapper greatly for a nozzle. That is, although a gas change contributes to improvement in an electrode life greatly, about a nozzle life, an improvement was not found or even the opposite effect understands a bird clapper for it. Therefore, even if the electrode life became long, the nozzle reached the life before it and the exchange interval of these articles of consumption did not become so long that it expects. even if it compares, it adopts this technology and an electrode life is improved (the number of times of arc ignition -- carrying out -- about 200 times to about 600 times), about the life of a nozzle, it is made the number of times of arc ignition, and is about at most 150 - 200 times, and the actual condition is not improved

[0010] It can divide roughly into following two as a factor of the damage of a nozzle. That is, by the time a nozzle shifts to a main arc so to speak from the case by the external factor which receives a damage, and a pilot arc because the molten metal (spatter) where it blows up toward a nozzle at the time of a piercing process (perforation process) adheres to a nozzle, current will flow into a nozzle by the pilot arc, and it is divided into the damage by melting of the outlet portion of a nozzle being carried out. As a remedy of the factor which has a bad influence on the

life of these nozzles, conventionally, about the former external damage, there is the method of protecting a nozzle from a spatter by preparing a shield cap in the outside of a nozzle, and it is adopted by most present plasma torches. However, about the damage by the pilot arc of the aforementioned latter, the indication with the method clear with the conventional technology of mitigating it is not yet found. In short, the electrode life and the nozzle life were made to extend simultaneously, and the technology of bringing about practically sufficient effect did not exist conventionally.

[0011] Usually, the damage is gradually expanded by melting of near the outlet of a nozzle being carried out by an electrode until it shifts to a main arc from a pilot arc, and the frequent pilot arc between nozzles, the sharpness of an arc becomes bad, and the life of a nozzle is judged in the stage in which the cutting process tolerance was less than predetermined default value to be a life, unless the electrode has resulted in the life.

[0012] On the other hand, a nozzle life is influenced by this electrode life although it is known that the temperature on arc during starting and the front face of an electrode will exhaust an electrode momentarily in the form where go up to the elevated temperature of about 3000 degreeC, and this electrode front face exfoliates by the thermal shock at this time. For example, when it results in a life with an electrode, damage destruction is rapidly carried out by the above-mentioned reason, at this time, the arc between an electrode and a work will stop in the nozzle under cutting process, a work will be replaced with this, a nozzle and an inter-electrode arc will generate it, and it will melt near the outlet of a nozzle in an instant as an arc melts a work (by the same principle). Thus, when the so-called damage on a path gap-nozzle occurs by this, and it has sharpness still sufficient as a nozzle just before it, when the damage on momentary of an electrode occurs, and having not resulted in the life, the actual condition will be in the state in which continuation use is impossible in an instant. Since it stated above, however it may take the prolongation-of-life measure of only a nozzle life conventionally, it concentrates on development of the life-extension technology of only an electrode, and it can say from the actual condition that a nozzle life is decided by the electrode life that an idea that it takes into consideration in the viewpoint to which nozzle life-extension technology and electrode life-extension technology were related had not attained to.

[0013] Moreover, the point that of course the numerousness of the exchange frequency by the life has had great influence also on the machine operating ratio fall (productivity fall) about the electrode and the nozzle at the cost [exhausting] accompanying exchange of an electrode and a nozzle is also a problem. Although it was the ideal which it is made to extend as long as the life of an electrode and a nozzle is made, respectively, and is simultaneously done for the set exchange of these (it considers as the same life) in order to solve this problem, an electrode life and each nozzle life of reality were irregular, and since a nozzle life was influenced as mentioned above by the sudden injury on an electrode, a margin must be seen and the actual condition could not but set up the lower number of times of a life.

[0014] Moreover, adoption of the transistor to arc ignition technology given in JP,6-15457,A is not what meant extension of a nozzle life as mentioned above. And it is used only as a switch as a chopper element which adjusts a pilot current, and the constant-current-control circuit for controlling the aforementioned transistor is needed apart from the constant-current-control circuit of a main arc current, and the transistor inserted in the pilot line becomes complicated [the power supply], and serves as cost quantity.

[0015] this invention is made paying attention to the above-mentioned trouble, and aims at offering the main arc ignition equipment and the main arc ignition control method both the lives and nozzle lives of a plasma electrode are extensible in a plasma cutting machine.

[0016]

[Means for Solving the Problem and its Function and Effect] on the occasion of this invention, artificers did research and development to the conventional gas change technology which mainly aimed at the improvement in an electrode life about the ignition control technology of the optimal PILOT circuit in which the nozzle life was also put into the visual field, and got the following conclusions

(1) The damage of a nozzle is caused by the current which flows into a nozzle at the time of

pilot-arc generating, the size of the current which gives the damage becomes so large that plasma gas becomes low voltage and a small flow rate, and that shortens the nozzle life in the gas change system contributed to the improvement in an electrode life.
(2) Moreover, the inrush current to a nozzle is in the inclination which the inflow current value increases, so that the type of gas of the plasma gas at the time of a pilot arc contains many nitrogen.
(3) And about the resistance inserted in a pilot line in series, when the pilot-arc current value of rating is about 20A and the resistance is less than 2ohms, the inrush current to a nozzle tends to increase extremely. Therefore, in this case, the resistance of a pilot circuit has desirable 2ohms or more.
(4) In order to improve a nozzle life, once it not only lowers the size of the inrush current to a nozzle, but detects main current using the level of detection of low main current as much as possible, since intercepting a pilot circuit immediately can lessen the injury on a nozzle, it is desirable. Therefore, although the level of main current detection should be set up low and the pilot arc should be immediately intercepted after detection, since about 50 msecs will be overdue if the timing of interception uses mechanical open/close switches, such as the conventional electromagnetic switch, it is desirable to use solid state switches (a transistor, a thyristor, IGBT, etc.). Moreover, a solid state switch is purely used as a switch in this case, and chopper control like the technology indicated by JP,6-15457,A mentioned above is not performed. Since the technical problem about the life extension of the above-mentioned article of consumption was solvable by incorporating the above-mentioned conclusion obtained by research and development like the above, the achievement means and effect are explained below.
[0017] In order to attain the purpose of the above-mentioned invention in this application, the 1st invention In the main arc ignition equipment of a plasma cutting machine an arc starting front stirrup immediately after Plasma gas is supplied to a plasma torch with a small flow rate and/or low gas pressure. after ignition of a pilot arc or a main arc The gas supply means which established the gas change means which changes this quantity of gas flow or gas pressure so that plasma gas might be supplied with a large flow rate and/or high gas pressure, The pilot-current circuit which supplies a pilot current to a nozzle from a plasma power supply in case a pilot arc is formed between the electrode of a plasma torch, and a nozzle at arc during starting, The main current circuit which supplies main current to a main arc from a plasma power supply in case a main arc is formed between the electrode of a plasma torch, and a work at the time of work cutting, It has the main current detector which was formed in the line connected with the work of the aforementioned main current circuit and which detects main current. After the aforementioned main current detector detects main current on the line connected with the nozzle of the aforementioned pilot-current circuit, it is considering as the composition equipped with the solid state switch which intercepts the aforementioned pilot current.
[0018] In the 1st invention, first, in case a pilot arc is formed between an electrode and a nozzle, since the arc starting front stirrup made the plasma gas passed between an electrode and a nozzle a small flow rate and/or low gas pressure immediately after, by the gas change means, the force which blows a pilot arc on a work side becomes small, consequently the pilot current Ip included in a nozzle becomes easy to flow, and it becomes possible also for a small current to form [of an arc] this pilot current Ip. Moreover, on the other hand, although exhausting an electrode momentarily in an arc generate time and the form where this electrode front face exfoliates by the thermal shock at this time is known, since a pilot current Ip can be managed with a small current, the damage of the electrode by the aforementioned thermal shock can be sharply reduced at the time of arc ignition.
[0019] According to the 1st invention, since a large flow rate and/or the plasma gas of high gas pressure are supplied between an electrode and a nozzle after ignition of a pilot arc or a main arc, the force which blows a pilot arc on a work side becomes large, and a pilot current Ip stops [next] easily being able to flow due to the aforementioned gas change means between an electrode and a nozzle. And since the current of a plasma power supply is shunted toward a pilot current Ip and main current Im, if a pilot current Ip decreases, main current Im will increase on

the contrary. Consequently, the shift to the main arc between an electrode and a work from a pilot arc is performed very promptly. Moreover, exhaustion of the electrode by the aforementioned thermal shock by arc ignition decreases for low-gas-pressure atmosphere. as mentioned above, by preparing a gas change means in a gas supply means, and an arc starting front stirrup's supplying plasma gas with a small flow rate and/or low gas pressure immediately after, and changing to a large flow rate and/or high gas pressure after ignition of a pilot arc or a main arc, to about about 600 times, the life of an electrode was boiled markedly and has improved by the number of times of arc ignition

[0020] Moreover, in the 1st invention, the effect of extension of a fast nozzle life which is stated below by composition which adopted the transistor in order to intercept a pilot current in addition to the effect of extension of the electrode life mentioned above was also able to be acquired. Although the state where a part of arc is still connected between an electrode and a nozzle, and the pilot current Ip is flowing to the nozzle after shifting to the main arc between an electrode and a work is continuing from the pilot arc, for this reason, the outlet portion of a nozzle lips edge is in the situation in which melting is always carried out by the aforementioned arc. Therefore, as for the facts and artificers who are a reason with it better [to shorten time to which the pilot current Ip is flowing between the electrode and the nozzle as much as possible, after shifting to this main arc, in order to prolong a nozzle life], the damage of the nozzle by the pilot arc has acquired the fact which is proportional at the size and time of the current included in a nozzle by the experimental result. Then, in order to intercept the pilot current Ip to a nozzle after main arcing Since it changed to the conventional electromagnetic switch and the transistor was adopted as the line connected with the nozzle of a pilot-current circuit the electromagnetic switch of the former [interrupting time / of a pilot current Ip] -- comparing -- markedly -- alike -- quick (as opposed to about 50 msec(s) of an electromagnetic switch) With the transistor, since the time when melting of the outlet portion of a nozzle lips edge is always carried out by the aforementioned arc in about 5 msec(s) decreased sharply, the life of a nozzle has improved by leaps and bounds compared with the former about 3 times (from about 150 - 200 conventional times to about 600 times [Being the number of times of arc ignition.]).

[0021] An electrode life -- the sudden injury on the electrode by the thermal shock will be conventionally damaged in [a nozzle] path gap -- and each nozzle life are irregular. Although it was the ideal which cannot but see a margin and the actual condition cannot but set up the lower number of times of a life, it is made to extend as long as an electrode life and a nozzle life are made, respectively, and is simultaneously done for the set exchange of these (it considers as the same life) The value of each life was enabled to be both able to improve the life of an electrode and a nozzle sharply, and to suppose that it is almost the same (being the number of times of arc ignition about about 600 times) by **** 1 invention as mentioned above. Therefore, the exchange frequency by the life could be sharply decreased by life improvement of this electrode and a nozzle, and the great effect was acquired not to mention the improvement of the article-of-consumption cost accompanying exchange by the improvement in a machine operating ratio (improvement in productivity). in addition, the technology which enabled extension of the above electrode life and nozzle life simultaneously results in this invention on originality and creativity paying attention to the viewpoint overlooked conventionally [whether it was what cannot aim at extension of a nozzle life] at the same time not combination but the nozzle life of the mere conventional technology have correlation in an electrode life and prolongs an electrode life

[0022] Next, the 2nd invention is taken as the composition which inserted resistance at the aforementioned solid state switch and the serial in the 1st invention at the line connected with the nozzle of the aforementioned pilot-current circuit.

[0023] Although the damage of the nozzle by the pilot arc has acquired the fact which is proportional at the size and time of the current included in a nozzle from the experimental result and the damage of a nozzle is caused by the current included in a nozzle as this invention persons mentioned above By having inserted resistance in the line connected with the nozzle of a pilot-current circuit according to **** 2 invention While a pilot current falls and making the injury on a nozzle mitigate, when main current increases contrary to this with the fall of a pilot

current with the property of a plasma constant current power supply Generating of a main arc and the shift to a main arc can be performed stably and quickly.
[0024] It is characterized by the aforementioned plasma gas from which the 3rd invention supplies an arc starting front stirrup to a plasma torch with a small flow rate and/or low gas pressure immediately after in the 1st invention being nitrogen or gas containing comparatively many nitrogen.
[0025] Usually, in plasma cutting, HAFUNYUUMU of the electrode material currently embedded immediately after lighting a pilot arc focusing on the electrode is intense, and exhaustion advances. In **** 3 invention, since nitrogen or the gas containing comparatively many nitrogen was used as plasma gas supplied around an electrode, the nitride of HAFUNYUUMU will be formed in the point of an electrode, and since this HAFUNYUUMU nitride has the high melting point, it can lessen exhaustion of an electrode. Therefore, an electrode wear is suppressed to arc during starting, and an electrode life can be extended.
[0026] In case the 4th invention supplies plasma gas to a plasma torch in the main arc ignition control method of a plasma cutting machine, an arc starting front stirrup moreover, in immediately after After it supplies plasma gas with a small flow rate and/or low gas pressure and a pilot arc or a main arc lights between the electrode of a plasma torch, and a nozzle While changing plasma gas to a large flow rate and/or high gas pressure, when generating of the main arc between the aforementioned electrode and a work is detected It is considering as the method of intercepting the aforementioned pilot current quickly by the solid state switch inserted in resistance and the serial at the line connected with the aforementioned nozzle of the pilot-current circuit which supplies a pilot current to the aforementioned pilot arc.
[0027] according to the 4th invention, since extension of a life with large electrode and nozzle can be aimed at in a plasma cutting machine like the 1st invention by this main arc ignition control method, the exchange frequency of an electrode and a nozzle is boiled markedly, and can be reduced, and the great effect of the improvement in a machine operating ratio (improvement in productivity) is acquired not to mention reduction of the article-of-consumption cost accompanying exchange of an electrode and a nozzle
[0028]
[Embodiments of the Invention] Below, the operation gestalt of this invention is explained in detail with reference to drawing 1 , drawing 2 , and drawing 3 . It is drawing which drawing 1 is the outline circuit diagram of the main arc ignition equipment concerning this invention, and expressed the pilot arc which drawing 2 requires for this invention here. Moreover, drawing 3 is the timing diagram of the plasma-gas flow concerning this invention. In addition, the same sign is attached to the same composition as the component in drawing 4 , and the following explanation is omitted.
[0029] In drawing 1 , the main arc ignition equipment of a plasma cutting machine is equipped with the constant current power supply 8 as a plasma power supply for supplying power to a torch 1. The minus output of a constant current power supply 8 is connected to electrode 1a of a torch 1 via the power supply line 20, and the plus output of a constant current power supply 8 branches on the two-line line of the pilot-current circuit 21 which supplies a pilot current Ip, and the main current circuit 22 which supplies main current Im, and is connected to nozzle 1b and the work 11, respectively.
[0030] The resistance 12 for making the aforementioned pilot-current circuit 21 shift to the main arc 13 formed between electrode 1a and a work 11 smoothly from the pilot arc 16 (to refer to drawing 2) formed between electrode 1a and nozzle 1b, It connects in series and the pilot-current detector 5 which detects the pilot current Ip which flows between the transistor 10 for switching which is the feature of this invention, and electrode 1a and nozzle 1b is formed. The control-command signal from the controller which is not illustrated is connected to the base of a transistor 10. Here, in the experiment which artificers conducted, since it was in the inclination which the inrush current to a nozzle increases extremely as the resistance of the above-mentioned resistance 12 is less than 2ohms when it was the cutting machine of the specification whose rated pilot-arc current is about 20A, the resistance was understood that 2ohms or more are desirable. In addition, according to the experimental result, 4-8ohm of resistance are

desirable. Moreover, what operates at high speed like IGBT as a switching element is used for a transistor 10. In addition, you may add the circuit for surge absorption (not shown) which consists of diodes for absorbing the surge at the time of switching etc. to the pilot-current circuit 21 if needed.

[0031] Moreover, since the main arc 13 shown in drawing 1 by guidance of the pilot arc 16 shown in drawing 2 is formed, the main current detector 6 for detecting that main current Im flowed between electrode 1a and the work 11 is inserted in the aforementioned main current circuit 22. If the current transformer which used shunt resistance and the hall device is used for this main current detector 6, for example, an about 3A small current flows to the main current circuit 22, the transistor 10 of the pilot-current circuit 21 will be turned off immediately, and it will consider as the composition which makes the pilot current Ip which is flowing between electrode 1a and nozzle 1b intercept in an instant.

[0032] In order to improve a nozzle life, once it not only lowers the value of the inrush current to nozzle 1b, but it sets up the disregard level of the lowest possible main current Im and this setting disregard level detects main current Im, since intercepting the pilot-current circuit 21 immediately can lessen damage on a nozzle, it is desirable. Therefore, after detection, the level of main current detection is set up as low as possible, and the pilot arc should be intercepted immediately, and by this invention, in order to accelerate the timing of this interception, electronic-formula switches (solid state switch), such as a transistor and IGBT, are used. by this, the timing of interception checked that that in which about 50 msecs were behind according to the opening and closing of the conventional mechanical contact improved to about 5 msecs, and it checked that also boiled the life of nozzle 1b markedly and it was protracted with the life of electrode 1a in connection with this

[0033] In the main arc ignition equipment of this invention, moreover, for the improvement in a life of electrode 1a as a gas supply means 2 to supply plasma gas to a torch 1 Gas stop valve 3a for a start which performs supply or interception of the gas for a start as shown in drawing 1 , The gas pipe way 4 which connects to a torch 1 gas change meanses 3 by which gas stop valve 3b for cutting which performs supply or interception of the gas for cutting was provided, and such gas stop valve 3a for a start and gas stop valve 3b for cutting is formed.

[0034] First, arc starting opens only gas stop valve 3a for a start from a pulley flow, and supplies the change to gas stop valve 3a for these starts, and gas stop valve 3b for cutting to the gas supply way which formed the gas for a start between electrode 1a in a torch 1, and nozzle 1b through the gas pipe way 4. About the gas for the start at this time (pulley flow), as shown in drawing 3 , as compared with the gas at the time of cutting, it is low gas pressure and/or a low flow rate, and is considering as the gas containing many pure nitrogen or nitrogen. Next, if a pilot arc 16 occurs between electrode 1a and nozzle 1b, the pilot-current detector 5 will detect the pilot current Ip which flows between electrode 1a and nozzle 1b through this pilot arc 16, this detecting signal will open gas stop valve 3b for cutting, and the gas for cutting will be supplied to a plasma torch 1. This gas for cutting is high gas pressure and/or a large flow rate as compared with the aforementioned gas for a start (pulley flow), as shown in drawing 3 , and it is gas containing many pure oxygen or oxygen. In addition, while opening gas stop valve 3b for cutting, gas stop valve 3a for a start could be closed, and as long as it was putting in the check valve in series with gas stop valve 3a for a start, it may open.

[0035] According to this operation form, the following operations and an effect are acquired.

(1) By composition of this invention, since the plasma gas passed in the meantime was made into a small flow rate and/or low gas pressure when forming a pilot arc between an electrode and a nozzle, the force which blows a pilot arc on a work side becomes small, consequently the pilot current Ip which flows for a nozzle becomes easy to flow, and it becomes possible also for a small current to form [of a pilot arc] this pilot current Ip. And since the pilot current Ip which flows between an electrode and a nozzle to a pilot-arc generate time can be managed with a small current, the damage of the electrode by the aforementioned thermal shock can be sharply reduced at the time of arc ignition.

[0036] Next, according to this invention, in the main arc ignition equipment of a plasma cutting machine, since a large flow rate and/or the plasma gas of high gas pressure are passed between

an electrode and a nozzle at the time of cutting, the force which blows a pilot arc on a work side becomes large, and a pilot current Ip stops easily being able to flow due to the composition which prepared the gas change means in the gas supply means between an electrode and a nozzle. And since the current of a constant current power supply is shunted toward a pilot current Ip and main current Im, if a pilot current Ip decreases as mentioned above, main current Im will increase relatively. Consequently, generating of the main arc between an electrode and a work and the shift to a main arc from a pilot arc are performed very promptly. Thus, by preparing a gas change means in a gas supply means, and an arc starting front stirrup's supplying gas to immediately after with a small flow rate and/or low gas pressure, and changing a pilot-arc ignition rear stirrup to a large flow rate and/or high gas pressure after main arc ignition, the life of an electrode is the number of times of arc ignition, and it was secured about about 600 times.
[0037] (2) Moreover, in this invention, in order to intercept a pilot current Ip, solid state switches, such as a transistor, were adopted. an electromagnetic switch [like before by this] whose interrupting time of a pilot current Ip is -- comparing -- markedly -- alike -- quick (as opposed to about 50 msec(s) of an electromagnetic switch) Since the time when melting of the outlet portion of a nozzle lips edge is always carried out by the aforementioned plasma arc in about 5 msec(s) decreases sharply with a transistor, the life of a nozzle Compared with the former, it has been improved by leaps and bounds with about 3 times (from about 150 - 200 times conventional by the number of times of arc ignition to about 600 times).
[0038] (3) Moreover, resistance is inserted in the pilot-current circuit connected to a nozzle, by setting this resistance to 2ohms or more, the pilot current Ip to a nozzle falls and damage on a nozzle can be mitigated. Moreover, when main current Im increases with the fall of a pilot current Ip with this by the above-mentioned reason, it can be stabilized, generating of a main arc and the shift to a main arc can be performed quickly, and a nozzle life and an electrode life can be prolonged sharply. Furthermore, since the potential difference between a nozzle and a work becomes large by having enlarged the above-mentioned resistance, the shift to a main arc can be performed easily.
[0039] (4) In plasma cutting, although consumption will advance violently, since the gas which contains many nitrogen or nitrogen as plasma gas of the electrode circumference was used for HAFUNYUUMU of the electrode material currently embedded immediately after lighting a pilot arc at an electrode focusing on the electrode by this invention, the nitride of HAFUNYUUMU will be formed in the point of an electrode, and since this HAFUNYUUMU nitride has the high melting point, it can lessen an electrode wear. Therefore, the electrode wear was suppressed to arc during starting, and the effect which prolongs an electrode life was acquired. In addition, the increase in the nozzle damage by the fall of the main arc translatability by using nitrogen for arc during starting is eliminated by having used the solid state switch.
[0040] (5) The length of each life was enabled to be both able to improve the life of an electrode and a nozzle sharply, and to suppose that it is almost the same (being the number of times of arc ignition about about 600 times) by composition of the above this inventions. Therefore, by life improvement of this electrode and a nozzle, the electrode in a long interval and set exchange of a nozzle are enabled, the exchange frequency can be decreased sharply, and a great effect is acquired by the improvement in a machine operating ratio (rise of productivity) not to mention the improvement of the article-of-consumption cost accompanying exchange of an electrode and a nozzle.

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TECHNICAL FIELD

[The technical field to which invention belongs] Especially this invention relates to the main arc ignition equipment to which cutting which repeats arc starting frequently can aim at extension of the life of a plasma electrode and a nozzle, and its main arc ignition control method about the main arc ignition equipment of a plasma cutting machine, and the main arc ignition control method.

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PRIOR ART

[Description of the Prior Art] Since the running cost in the case of exchange of that degradation of the plasma electrode and a nozzle lowers the quality of a direct workpiece, an electrode, and a nozzle increases conventionally in the plasma-arc cutting process of metal plate material (it is henceforth called a work), various research and development continued being done about these lives.
[0003] first, in order to make an understanding of this invention easy, drawing 4 which expressed the general composition and the plasma-arc starting method of a plasma cutting machine for the most fundamental cutting machine that uses oxygen as plasma gas, and its control method as conventional technology of a plasma cutting machine, and drawing 5 which is the timing diagram of the operating sequence showing the arc starting control method of this plasma cutting machine are illuminated 3, and is explained In drawing 4 (a) and drawing 5 , if a seizure signal ST is inputted into a plasma cutting machine, a constant current power supply 8 will operate, a switch (electromagnetic switch) 14 will close, and direct current voltage will be impressed so that nozzle 1b and a work 11 may be [electrode 1a in a plasma torch 1] added at minus. Simultaneously, a stop valve 15 opens and the oxygen gas as a pulley flow is supplied in a plasma torch 1. This pulley flow is established in order to acquire a time margin until a quantity of gas flow is stabilized, while replacing the air in the gas pipe way 4 by oxygen completely. If a high frequency generator 9 operates and the RF high voltage is impressed between electrode 1a and nozzle 1b in drawing 4 (b) after the above-mentioned pulley flow, as spark discharge happens between this electrode 1a and this nozzle 1b and it is shown in drawing 4 (c) A pilot arc 16 is formed between electrode 1a and nozzle 1b by using this spark discharge as a seed. A pilot current Ip flows the circuit which returns to a constant current power supply 8 via electrode 1a from nozzle 1b and a pilot arc 16 through a constant current power supply 8 to resistance 12 and a switch 14. It is in the state where a constant current power supply 8 takes out the maximum output simply at this time, that is, the drooping characteristic is given by resistance 12, and since it is functioning as a source of a constant voltage mostly, the aforementioned pilot current Ip is stabilized after a power requirement and arc voltage have balanced.
[0004] And if an electric flow is secured between electrode 1a and nozzle 1b by considering this pilot arc 16 as guidance as shown in drawing 4 (d), a part of aforementioned pilot current Ip will turn into main current Im, it will flow to a work 11, and will form the main arc 13. As the current detector which does not illustrate this detects and it is shown in drawing 4 (e), by separating the switch 14 which leads to nozzle 1b, it becomes the circuit of only the main arc 13 and only main current Im flows. And cutting current value set up beforehand (main current Im) Comparing the output value and this set point of a current detector which are not illustrated so that it may maintain, constant current control is performed and cutting processing of a work 11 is carried out. Then, at the time of a cutting end, a stop signal SP is supplied to a power supply, the output of a power supply stops, supply of the power to the main arc 13 stops, and the main arc 13 disappears.
[0005] A main arc detection means detecting a main arc, and this detecting signal opening the aforementioned switch (electromagnetic switch), intercepting a pilot arc, and lighting a main arc, after it puts resistance and a switch (electromagnetic switch) into a pilot circuit in series as

conventional technology and a pilot arc occurs like the above is the technology currently very generally performed in the plasma-cutting machine.
[0006] As a technical technical problem in a plasma cutting machine, first, the reinforcement of an article of consumption occurs and, for the reason, much invention and the design have so far been made. There is JP,5-104251,A as the 1st advanced technology. It is reported to this official report as how to pass the plasma gas supplied to a plasma torch by the technology which changes plasma gas to the high gas pressure from low gas pressure, or a large flow rate from a small flow rate just behind arc ignition that there was the reduction effect of an electrode wear.
[0007] Moreover, arc during starting and an arc starting front stirrup supply a non-oxidizing quality gas to a plasma torch as plasma gas immediately after, the technology which changes plasma gas to an oxidizing quality gas is indicated by JP,3-258464,A shown as the 2nd advanced technology, with the change technology of these types of gas, an electrode wear can be reduced and after arc ignition supposes at it that an electrode life will be extensible.
[0008] And in order to improve the translatability from a pilot arc to a main arc, the technology which adopted not an electromagnetic switch but the transistor is indicated by JP,6-15457,A shown as the 3rd advanced technology as the aforementioned switch at the time of the ignition detecting signal of a main arc opening a switch, and intercepting a pilot arc. About secondary chopper control of a pilot current, this technology is not considering a transistor as a simple switch, and is operated as a chopper control element. And during pilot-arc generating, since the circuit of a main arc carries out a full output and can take the voltage large enough between an electrode required for shift, and a base material, or between a nozzle and a base material, it prevents the shift mistake to a main arc, and shift delay, and supposes that a suitable power unit can be offered.

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EFFECT OF THE INVENTION

[Means for Solving the Problem and its Function and Effect] on the occasion of this invention, artificers did research and development to the conventional gas change technology which mainly aimed at the improvement in an electrode life about the ignition control technology of the optimal PILOT circuit in which the nozzle life was also put into the visual field, and got the following conclusions
(1) The damage of a nozzle is caused by the current which flows into a nozzle at the time of pilot-arc generating, the size of the current which gives the damage becomes so large that plasma gas becomes low voltage and a small flow rate, and that shortens the nozzle life in the gas change system contributed to the improvement in an electrode life.
(2) Moreover, the inrush current to a nozzle is in the inclination which the inflow current value increases, so that the type of gas of the plasma gas at the time of a pilot arc contains many nitrogen.
(3) And about the resistance inserted in a pilot line in series, when the pilot-arc current value of rating is about 20A and the resistance is less than 2ohms, the inrush current to a nozzle tends to increase extremely. Therefore, in this case, the resistance of a pilot circuit has desirable 2ohms or more.
(4) In order to improve a nozzle life, once it not only lowers the size of the inrush current to a nozzle, but detects main current using the level of detection of low main current as much as possible, since intercepting a pilot circuit immediately can lessen the injury on a nozzle, it is desirable. Therefore, although the level of main current detection should be set up low and the pilot arc should be immediately intercepted after detection, since about 50 msecs will be overdue if the timing of interception uses mechanical open/close switches, such as the conventional electromagnetic switch, it is desirable to use solid state switches (a transistor, a thyristor, IGBT, etc.). Moreover, a solid state switch is purely used as a switch in this case, and chopper control like the technology indicated by JP,6-15457,A mentioned above is not performed. Since the technical problem about the life extension of the above-mentioned article of consumption was solvable by incorporating the above-mentioned conclusion obtained by research and development like the above, the achievement means and effect are explained below.
[0017] In order to attain the purpose of the above-mentioned invention in this application, the 1st invention In the main arc ignition equipment of a plasma cutting machine an arc starting front stirrup immediately after Plasma gas is supplied to a plasma torch with a small flow rate and/or low gas pressure. after ignition of a pilot arc or a main arc The gas supply means which established the gas change means which changes this quantity of gas flow or gas pressure so that plasma gas might be supplied with a large flow rate and/or high gas pressure, The pilot-current circuit which supplies a pilot current to a nozzle from a plasma power supply in case a pilot arc is formed between the electrode of a plasma torch, and a nozzle at arc during starting, The main current circuit which supplies main current to a main arc from a plasma power supply in case a main arc is formed between the electrode of a plasma torch, and a work at the time of work cutting, It has the main current detector which was formed in the line connected with the work of the aforementioned main current circuit and which detects main current. After the

aforementioned main current detector detects main current on the line connected with the nozzle of the aforementioned pilot-current circuit, it is considering as the composition equipped with the solid state switch which intercepts the aforementioned pilot current.
[0018] In the 1st invention, first, in case a pilot arc is formed between an electrode and a nozzle, since the arc starting front stirrup made the plasma gas passed between an electrode and a nozzle a small flow rate and/or low gas pressure immediately after, by the gas change means, the force which blows a pilot arc on a work side becomes small, consequently the pilot current Ip included in a nozzle becomes easy to flow, and it becomes possible also for a small current to form [of an arc] this pilot current Ip. Moreover, on the other hand, although exhausting an electrode momentarily in an arc generate time and the form where this electrode front face exfoliates by the thermal shock at this time is known, since a pilot current Ip can be managed with a small current, the damage of the electrode by the aforementioned thermal shock can be sharply reduced at the time of arc ignition.
[0019] According to the 1st invention, since a large flow rate and/or the plasma gas of high gas pressure are supplied between an electrode and a nozzle after ignition of a pilot arc or a main arc, the force which blows a pilot arc on a work side becomes large, and a pilot current Ip stops [next] easily being able to flow due to the aforementioned gas change means between an electrode and a nozzle. And since the current of a plasma power supply is shunted toward a pilot current Ip and main current Im, if a pilot current Ip decreases, main current Im will increase on the contrary. Consequently, the shift to the main arc between an electrode and a work from a pilot arc is performed very promptly. Moreover, consumption of the electrode by the aforementioned thermal shock by arc ignition decreases for low-gas-pressure atmosphere. as mentioned above, by preparing a gas change means in a gas supply means, and an arc starting front stirrup's supplying plasma gas with a small flow rate and/or low gas pressure immediately after, and changing to a large flow rate and/or high gas pressure after ignition of a pilot arc or a main arc, to about about 600 times, the life of an electrode was boiled markedly and has improved by the number of times of arc ignition
[0020] Moreover, in the 1st invention, the effect of extension of a fast nozzle life which is stated below by composition which adopted the transistor in order to intercept a pilot current in addition to the effect of extension of the electrode life mentioned above was also able to be acquired. Although the state where a part of arc is still connected between an electrode and a nozzle, and the pilot current Ip is flowing to the nozzle after shifting to the main arc between an electrode and a work is continuing from the pilot arc, for this reason, the outlet portion of a nozzle lips edge is in the situation in which melting is always carried out by the aforementioned arc. Therefore, as for the facts and artificers who are a reason with it better [to shorten time to which the pilot current Ip is flowing between the electrode and the nozzle as much as possible, after shifting to this main arc, in order to prolong a nozzle life], the damage of the nozzle by the pilot arc has acquired the fact which is proportional at the size and time of the current included in a nozzle by the experimental result. Then, in order to intercept the pilot current Ip to a nozzle after main arcing Since it changed to the conventional electromagnetic switch and the transistor was adopted as the line connected with the nozzle of a pilot-current circuit the electromagnetic switch of the former [interrupting time / of a pilot current Ip] -- comparing -- markedly -- alike -- quick (as opposed to about 50 msec(s) of an electromagnetic switch) With the transistor, since the time when melting of the outlet portion of a nozzle lips edge is always carried out by the aforementioned arc in about 5 msec(s) decreased sharply, the life of a nozzle has improved by leaps and bounds compared with the former about 3 times (from about 150 - 200 conventional times to about 600 times [Being the number of times of arc ignition.]).
[0021] An electrode life -- the sudden damage on the electrode by the thermal shock will be conventionally damaged in [a nozzle] path gap -- and each nozzle life are irregular. Although it was the ideal which cannot but see a margin and the actual condition cannot but set up the lower number of times of a life, it is made to extend as long as an electrode life and a nozzle life are made, respectively, and is simultaneously done for the set exchange of these (it considers as the same life) The value of each life was enabled to be both able to improve the life of an electrode and a nozzle sharply, and to suppose that it is almost the same (being the number of

times of arc ignition about about 600 times) by **** 1 invention as mentioned above. Therefore, the exchange frequency by the life could be sharply decreased by life improvement of this electrode and a nozzle, and the great effect was acquired not to mention the improvement of the article-of-consumption cost accompanying exchange by the improvement in a machine operating ratio (improvement in productivity). in addition, the technology which enabled extension of the above electrode life and nozzle life simultaneously results in this invention on originality and creativity paying attention to the viewpoint overlooked conventionally [whether it was what cannot aim at extension of a nozzle life] at the same time not combination but the nozzle life of the mere conventional technology have correlation in an electrode life and prolongs an electrode life

[0022] Next, the 2nd invention is taken as the composition which inserted resistance at the aforementioned solid state switch and the serial in the 1st invention at the line connected with the nozzle of the aforementioned pilot-current circuit.

[0023] Although the damage of the nozzle by the pilot arc has acquired the fact which is proportional at the size and time of the current included in a nozzle from the experimental result and the damage of a nozzle is caused by the current included in a nozzle as this invention persons mentioned above By having inserted resistance in the line connected with the nozzle of a pilot-current circuit according to **** 2 invention While a pilot current falls and making damage on a nozzle mitigate, when main current increases contrary to this with the fall of a pilot current with the property of a plasma constant current power supply Generating of a main arc and the shift to a main arc can be performed stably and quickly.

[0024] It is characterized by the aforementioned plasma gas from which the 3rd invention supplies an arc starting front stirrup to a plasma torch with a small flow rate and/or low gas pressure immediately after in the 1st invention being nitrogen or gas containing comparatively many nitrogen.

[0025] Usually, in plasma cutting, HAFUNYUUMU of the electrode material currently embedded immediately after lighting a pilot arc focusing on the electrode is intense, and consumption advances. In **** 3 invention, since nitrogen or the gas containing comparatively many nitrogen was used as plasma gas supplied around an electrode, the nitride of HAFUNYUUMU will be formed in the point of an electrode, and since this HAFUNYUUMU nitride has the high melting point, it can lessen consumption of an electrode. Therefore, an electrode wear is suppressed to arc during starting, and an electrode life can be extended.

[0026] In case the 4th invention supplies plasma gas to a plasma torch in the main arc ignition control method of a plasma cutting machine, an arc starting front stirrup moreover, in immediately after After it supplies plasma gas with a small flow rate and/or low gas pressure and a pilot arc or a main arc lights between the electrode of a plasma torch, and a nozzle While changing plasma gas to a large flow rate and/or high gas pressure, when generating of the main arc between the aforementioned electrode and a work is detected It is considering as the method of intercepting the aforementioned pilot current quickly by the solid state switch inserted in resistance and the serial at the line connected with the aforementioned nozzle of the pilot-current circuit which supplies a pilot current to the aforementioned pilot arc.

[0027] according to the 4th invention, since extension of a life with large electrode and nozzle can be aimed at in a plasma cutting machine like the 1st invention by this main arc ignition control method, the exchange frequency of an electrode and a nozzle is boiled markedly, and can be reduced, and the great effect of the improvement in a machine operating ratio (improvement in productivity) is acquired not to mention reduction of the article-of-consumption cost accompanying exchange of an electrode and a nozzle

[0028]

[Embodiments of the Invention] Below, the operation form of this invention is explained in detail with reference to drawing 1 , drawing 2 , and drawing 3 . It is drawing which drawing 1 is the outline circuit diagram of the main arc ignition equipment concerning this invention, and expressed the pilot arc which drawing 2 requires for this invention here. Moreover, drawing 3 is the timing diagram of the plasma-gas flow concerning this invention. In addition, the same sign is attached to the same composition as the component in drawing 4 , and the following explanation

is omitted.
[0029] In drawing 1 , the main arc ignition equipment of a plasma cutting machine is equipped with the constant current power supply 8 as a plasma power supply for supplying power to a torch 1. The minus output of a constant current power supply 8 is connected to electrode 1a of a torch 1 via the power supply line 20, and the plus output of a constant current power supply 8 branches on the two-line line of the pilot-current circuit 21 which supplies a pilot current Ip, and the main current circuit 22 which supplies main current Im, and is connected to nozzle 1b and the work 11, respectively.
[0030] The resistance 12 for making the aforementioned pilot-current circuit 21 shift to the main arc 13 formed between electrode 1a and a work 11 smoothly from the pilot arc 16 (to refer to drawing 2) formed between electrode 1a and nozzle 1b, It connects in series and the pilot-current detector 5 which detects the pilot current Ip which flows between the transistor 10 for switching which is the feature of this invention, and electrode 1a and nozzle 1b is formed. The control-command signal from the controller which is not illustrated is connected to the base of a transistor 10. Here, in the experiment which artificers conducted, since it was in the inclination which the inrush current to a nozzle increases extremely as the resistance of the above-mentioned resistance 12 is less than 2ohms when it was the cutting machine of the specification whose rated pilot-arc current is about 20A, the resistance was understood that 2ohms or more are desirable. In addition, according to the experimental result, 4-8ohm of resistance are desirable. Moreover, what operates at high speed like IGBT as a switching element is used for a transistor 10. In addition, you may add the circuit for surge absorption (not shown) which consists of diodes for absorbing the surge at the time of switching etc. to the pilot-current circuit 21 if needed.
[0031] Moreover, since the main arc 13 shown in drawing 1 by guidance of the pilot arc 16 shown in drawing 2 is formed, the main current detector 6 for detecting that main current Im flowed between electrode 1a and the work 11 is inserted in the aforementioned main current circuit 22. If the current transformer which used shunt resistance and the hall device is used for this main current detector 6, for example, an about 3A small current flows to the main current circuit 22, the transistor 10 of the pilot-current circuit 21 will be turned off immediately, and it will consider as the composition which makes the pilot current Ip which is flowing between electrode 1a and nozzle 1b intercept in an instant.
[0032] In order to improve a nozzle life, once it not only lowers the value of the inrush current to nozzle 1b, but it sets up the disregard level of the lowest possible main current Im and this setting disregard level detects main current Im, since intercepting the pilot-current circuit 21 immediately can lessen damage on a nozzle, it is desirable. Therefore, after detection, the level of main current detection is set up as low as possible, and the pilot arc should be intercepted immediately, and by this invention, in order to accelerate the timing of this interception, electronic-formula switches (solid state switch), such as a transistor and IGBT, are used. by this, the timing of interception checked that that in which about 50 msecs were behind according to the opening and closing of the conventional mechanical contact improved to about 5 msecs, and it checked that also boiled the life of nozzle 1b markedly and it was protracted with the life of electrode 1a in connection with this
[0033] In the main arc ignition equipment of this invention, moreover, for the improvement in a life of electrode 1a as a gas supply means 2 to supply plasma gas to a torch 1 Gas stop valve 3a for a start which performs supply or interception of the gas for a start as shown in drawing 1 , The gas pipe way 4 which connects to a torch 1 gas change meanses 3 by which gas stop valve 3b for cutting which performs supply or interception of the gas for cutting was provided, and such gas stop valve 3a for a start and gas stop valve 3b for cutting is formed.
[0034] First, arc starting opens only gas stop valve 3a for a start from a pulley flow, and supplies the change to gas stop valve 3a for these starts, and gas stop valve 3b for cutting to the gas supply way which formed the gas for a start between electrode 1a in a torch 1, and nozzle 1b through the gas pipe way 4. About the gas for the start at this time (pulley flow), as shown in drawing 3 , as compared with the gas at the time of cutting, it is low gas pressure and/or a low flow rate, and is considering as the gas containing many pure nitrogen or nitrogen. Next, if a pilot

arc 16 occurs between electrode 1a and nozzle 1b, the pilot-current detector 5 will detect the pilot current Ip which flows between electrode 1a and nozzle 1b through this pilot arc 16, this detecting signal will open gas stop valve 3b for cutting, and the gas for cutting will be supplied to a plasma torch 1. This gas for cutting is high gas pressure and/or a large flow rate as compared with the aforementioned gas for a start (pulley flow), as shown in drawing 3 , and it is gas containing many pure oxygen or oxygen. In addition, while opening gas stop valve 3b for cutting, gas stop valve 3a for a start could be closed, and as long as it was putting in the check valve in series with gas stop valve 3a for a start, it may open.

[0035] According to this operation form, the following operations and an effect are acquired.

(1) By composition of this invention, since the plasma gas passed in the meantime was made into a small flow rate and/or low gas pressure when forming a pilot arc between an electrode and a nozzle, the force which blows a pilot arc on a work side becomes small, consequently the pilot current Ip which flows for a nozzle becomes easy to flow, and it becomes possible also for a small current to form [of a pilot arc] this pilot current Ip. And since the pilot current Ip which flows between an electrode and a nozzle to a pilot-arc generate time can be managed with a small current, the damage of the electrode by the aforementioned thermal shock can be sharply reduced at the time of arc ignition.

[0036] Next, according to this invention, in the main arc ignition equipment of a plasma cutting machine, since a large flow rate and/or the plasma gas of high gas pressure are passed between an electrode and a nozzle at the time of cutting, the force which blows a pilot arc on a work side becomes large, and a pilot current Ip stops easily being able to flow due to the composition which prepared the gas change means in the gas supply means between an electrode and a nozzle. And since the current of a constant current power supply is shunted toward a pilot current Ip and main current Im, if a pilot current Ip decreases as mentioned above, main current Im will increase relatively. Consequently, generating of the main arc between an electrode and a work and the shift to a main arc from a pilot arc are performed very promptly. Thus, by preparing a gas change means in a gas supply means, and an arc starting front stirrup's supplying gas to immediately after with a small flow rate and/or low gas pressure, and changing a pilot-arc ignition rear stirrup to a large flow rate and/or high gas pressure after main arc ignition, the life of an electrode is the number of times of arc ignition, and it was secured about about 600 times.

[0037] (2) Moreover, in this invention, in order to intercept a pilot current Ip, solid state switches, such as a transistor, were adopted. an electromagnetic switch [like before by this] whose interrupting time of a pilot current Ip is -- comparing -- markedly -- alike -- quick (as opposed to about 50 msec(s) of an electromagnetic switch) Since the time when melting of the outlet portion of a nozzle lips edge is always carried out by the aforementioned plasma arc in about 5 msec(s) decreases sharply with a transistor, the life of a nozzle Compared with the former, it has been improved by leaps and bounds with about 3 times (from about 150 - 200 times conventional by the number of times of arc ignition to about 600 times).

[0038] (3) Moreover, resistance is inserted in the pilot-current circuit connected to a nozzle, by setting this resistance to 2ohms or more, the pilot current Ip to a nozzle falls and the injury on a nozzle can be mitigated. Moreover, when main current Im increases with the fall of a pilot current Ip with this by the above-mentioned reason, it can be stabilized, generating of a main arc and the shift to a main arc can be performed quickly, and a nozzle life and an electrode life can be prolonged sharply. Furthermore, since the potential difference between a nozzle and a work becomes large by having enlarged the above-mentioned resistance, the shift to a main arc can be performed easily.

[0039] (4) In plasma cutting, although exhaustion will advance violently, since the gas which contains many nitrogen or nitrogen as plasma gas of the electrode circumference was used for HAFUNYUUMU of the electrode material currently embedded immediately after lighting a pilot arc at an electrode focusing on the electrode by this invention, the nitride of HAFUNYUUMU will be formed in the point of an electrode, and since this HAFUNYUUMU nitride has the high melting point, it can lessen an electrode wear. Therefore, the electrode wear was suppressed to arc during starting, and the effect which prolongs an electrode life was acquired. In addition, the increase in the nozzle damage by the fall of the main arc translatability by using nitrogen for arc

during starting is eliminated by having used the solid state switch.
[0040] (5) The length of each life was enabled to be both able to improve the life of an electrode and a nozzle sharply, and to suppose that it is almost the same (being the number of times of arc ignition about about 600 times) by composition of the above this inventions. Therefore, by life improvement of this electrode and a nozzle, the electrode in a long interval and set exchange of a nozzle are enabled, the exchange frequency can be decreased sharply, and a great effect is acquired by the improvement in a machine operating ratio (rise of productivity) not to mention the improvement of the article-of-consumption cost accompanying exchange of an electrode and a nozzle.

[Translation done.]

* NOTICES *

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] The technology only about the life extension of an electrode existed so that JP,5-104251,A shown as the 1st advanced technology of the above, JP,3-258464,A shown as 2nd advanced technology might see conventionally. However, if it is made a small flow rate or low voltage gas about the plasma-gas change of these conventional technology at during starting, it has turned out that the fault to which the translatability from a pilot arc to a main arc becomes bad, and the damage of a nozzle becomes large rather occurs recently. Moreover, by the gas containing many nitrogen or nitrogen, the translatability to a main arc became worse than oxygen, and a damage understands it also as a bird clapper greatly for a nozzle. That is, although a gas change contributes to improvement in an electrode life greatly, about a nozzle life, an improvement was not found or even the opposite effect understands a bird clapper for it. Therefore, even if the electrode life became long, the nozzle reached the life before it and the exchange interval of these articles of consumption did not become so long that it expects. even if it compares, it adopts this technology and an electrode life is improved (the number of times of arc ignition -- carrying out -- about 200 times to about 600 times), about the life of a nozzle, it is made the number of times of arc ignition, and is about at most 150 - 200 times, and the actual condition is not improved
[0010] It can divide roughly into following two as a factor of the damage of a nozzle. That is, by the time a nozzle shifts to a main arc so to speak from the case by the external factor which receives a damage, and a pilot arc because the molten metal (spatter) where it blows up toward a nozzle at the time of a piercing process (perforation process) adheres to a nozzle, current will flow into a nozzle by the pilot arc, and it is divided into the damage by melting of the outlet portion of a nozzle being carried out. As a remedy of the factor which has a bad influence on the life of these nozzles, conventionally, about the former external damage, there is the method of protecting a nozzle from a spatter by preparing a shield cap in the outside of a nozzle, and it is adopted by most present plasma torches. However, about the damage by the pilot arc of the aforementioned latter, the indication with the method clear with the conventional technology of mitigating it is not yet found. In short, the electrode life and the nozzle life were made to extend simultaneously, and the technology of bringing about practically sufficient effect did not exist conventionally.
[0011] Usually, the injury is gradually expanded by melting of near the outlet of a nozzle being carried out by an electrode until it shifts to a main arc from a pilot arc, and the frequent pilot arc between nozzles, the sharpness of an arc becomes bad, and the life of a nozzle is judged in the stage in which the cutting process tolerance was less than predetermined default value to be a life, unless the electrode has resulted in the life.
[0012] On the other hand, a nozzle life is influenced by this electrode life although it is known that the temperature on arc during starting and the front face of an electrode will exhaust an electrode momentarily in the form where go up to the elevated temperature of about 3000 degreeC, and this electrode front face exfoliates by the thermal shock at this time. For example, when it results in a life with an electrode, injury destruction is rapidly carried out by the above-mentioned reason, at this time, the arc between an electrode and a work will stop in the nozzle under cutting process, a work will be replaced with this, a nozzle and an inter-electrode arc will

generate it, and it will melt near the outlet of a nozzle in an instant as an arc melts a work (by the same principle). Thus, when the so-called injury on a path gap-nozzle occurs by this, and it has sharpness still sufficient as a nozzle just before it, when the injury on momentary of an electrode occurs, and having not resulted in the life, the actual condition will be in the state in which continuation use is impossible in an instant. Since it stated above, however it may take the prolongation-of-life measure of only a nozzle life conventionally, it concentrates on development of the life-extension technology of only an electrode, and it can say from the actual condition that a nozzle life is decided by the electrode life that an idea that it takes into consideration in the viewpoint to which nozzle life-extension technology and electrode life-extension technology were related had not attained to.

[0013] Moreover, the point that of course the numerousness of the exchange frequency by the life has had great influence also on the machine operating ratio fall (productivity fall) about the electrode and the nozzle at the cost [exhausting] accompanying exchange of an electrode and a nozzle is also a problem. Although it was the ideal which it is made to extend as long as the life of an electrode and a nozzle is made, respectively, and is simultaneously done for the set exchange of these (it considers as the same life) in order to solve this problem, an electrode life and each nozzle life of reality were irregular, and since a nozzle life was influenced as mentioned above by the sudden injury on an electrode, a margin must be seen and the actual condition could not but set up the lower number of times of a life.

[0014] Moreover, adoption of the transistor to arc ignition technology given in JP,6-15457,A is not what meant extension of a nozzle life as mentioned above. And it is used only as a switch as a chopper element which adjusts a pilot current, and the constant-current-control circuit for controlling the aforementioned transistor is needed apart from the constant-current-control circuit of a main arc current, and the transistor inserted in the pilot line becomes complicated [the power supply], and serves as cost quantity.

[0015] this invention is made paying attention to the above-mentioned trouble, and aims at offering the main arc ignition equipment and the main arc ignition control method both the lives and nozzle lives of a plasma electrode are extensible in a plasma cutting machine.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the outline circuit diagram of the main arc ignition equipment concerning this invention.
[Drawing 2] It is drawing showing the pilot arc concerning this invention.
[Drawing 3] It is the timing diagram of the plasma-gas flow concerning this invention.
[Drawing 4] They are the general composition of the plasma cutting machine of the conventional technology, and explanatory drawing of the plasma-arc starting method.
[Drawing 5] It is the timing diagram of the operating sequence showing the arc starting control method of the conventional technology.
[Description of Notations]
1 [-- A nozzle, 2 / -- A gas supply means, 3 / -- Gas change means,] -- A torch, 1a -- An electrode, 1b 3a [-- Gas pipe way,] -- The gas stop valve for a start, 3b -- The gas stop valve for cutting, 4 5 [-- Constant current power supply (plasma power supply),] -- A pilot-current detector, 6 -- A main current detector, 8 9 [-- Work,] -- A high frequency generator, 10 -- A transistor (solid state switch), 11 12 [-- A switch (electromagnetic switch), 15 / -- A stop valve, 16 / -- A pilot arc, 20 / -- A power supply line, 21 / -- A pilot-current circuit, 22 / -- A main current circuit, Ip / -- A pilot current, Im / -- Main current.] -- Resistance, 13 -- A main arc, 14

[Translation done.]

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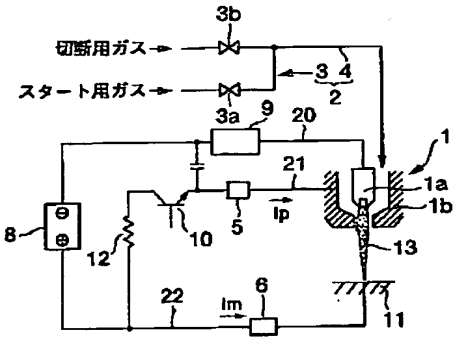
DRAWINGS

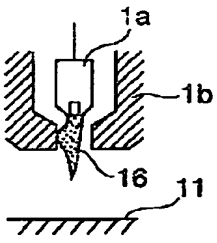
メインアーク着火装置の概要回路図



1：トーチ
1a：電極
1b：ノズル
2：ガス供給手段
3：ガス切り替え手段
8：プラズマ電源
10：半導体スイッチ
11：ワーク
12：抵抗
13：メインアーク
20：電源ライン
21：パイロット電流回路
22：メイン電流回路
Ip：パイロット電流
Im：メイン電流

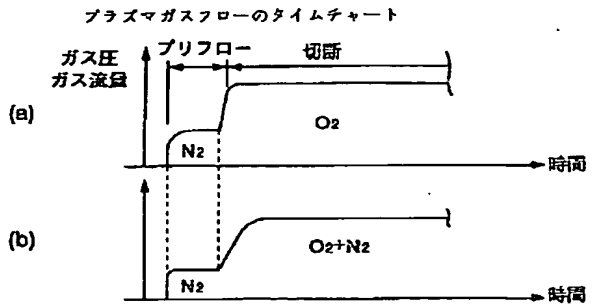
[Drawing 1]

パイロットアーク

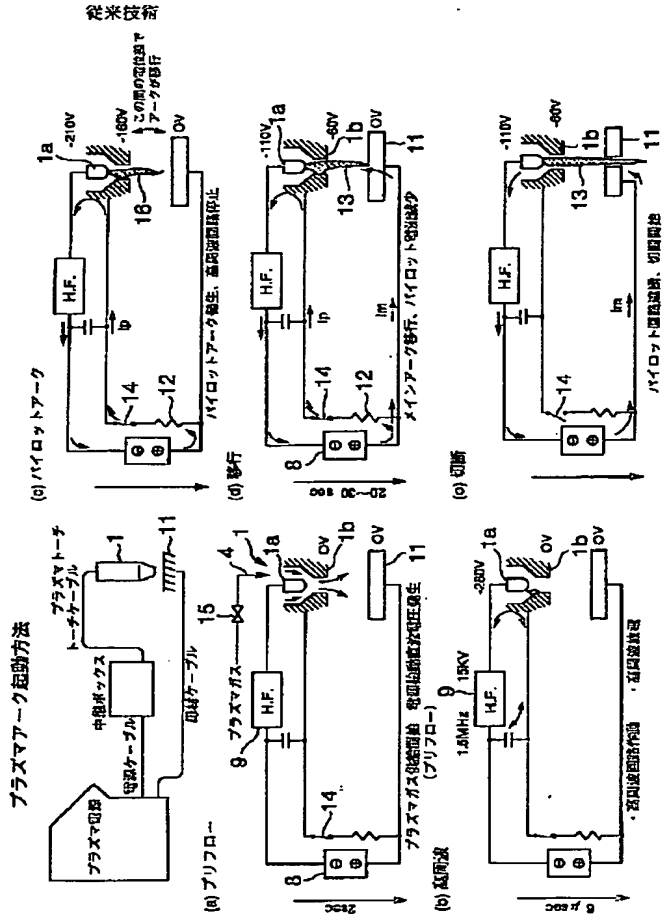


16：パイロット電流

[Drawing 2]

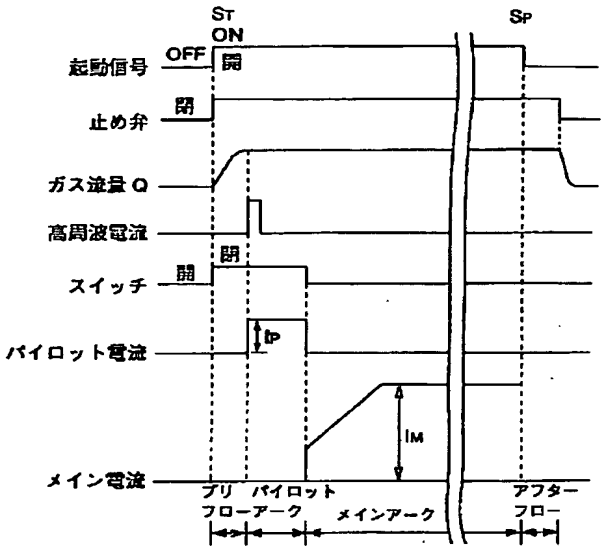


[Drawing 3]



[Drawing 4]

従来技術のアーク起動制御方法



[Drawing 5]

[Translation done.]